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Cutting tool insert having internal microduct for coolant

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US008047748B2

(12) **United States Patent**
Endres

(10) **Patent No.:** **US 8,047,748 B2**
(45) **Date of Patent:** ***Nov. 1, 2011**

(54) **CUTTING TOOL INSERT HAVING
INTERNAL MICRODUCT FOR COOLANT**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **12/885,123**

(22) Filed: **Sep. 17, 2010**

(65) **Prior Publication Data**

US 2011/0002750 A1 Jan. 6, 2011

Related U.S. Application Data

(63) Continuation of application No. 11/746,186, filed on
May 9, 2007, now Pat. No. 7,802,947.

(51) **Int. Cl.**

B23B 27/00 (2006.01)

B23B 27/02 (2006.01)

(52) **U.S. Cl.** **407/113; 407/115**

(58) **Field of Classification Search** **407/113,**
407/114, 115, 116

See application file for complete search history.

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Primary Examiner — Will Fridle, Jr.

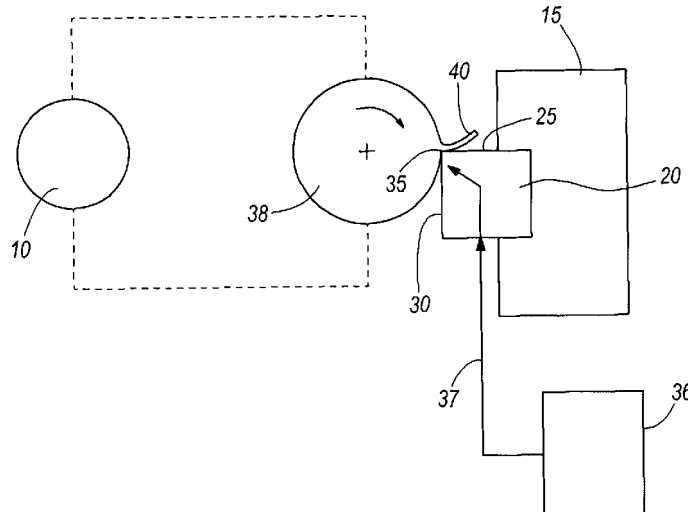
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ABSTRACT

A cutting tool insert includes: a body defining a rake face, a
flank face, and a cutting edge at an intersection of the rake and
flank faces; and a cooling microduct within the body. The
microduct has a cross-sectional area of not more than 1.0
square millimeter. The microduct is adapted to permit the
flow of a coolant therethrough to transfer heat away from the
cutting edge and extend the useful life of the insert. The
microduct may have a portion with a cross-sectional area no
larger than 0.004 square millimeter, and may communicate
through at least one of the rake face and the flank face to
exhaust coolant near the cutting edge and further enhance
cooling.

21 Claims, 7 Drawing Sheets



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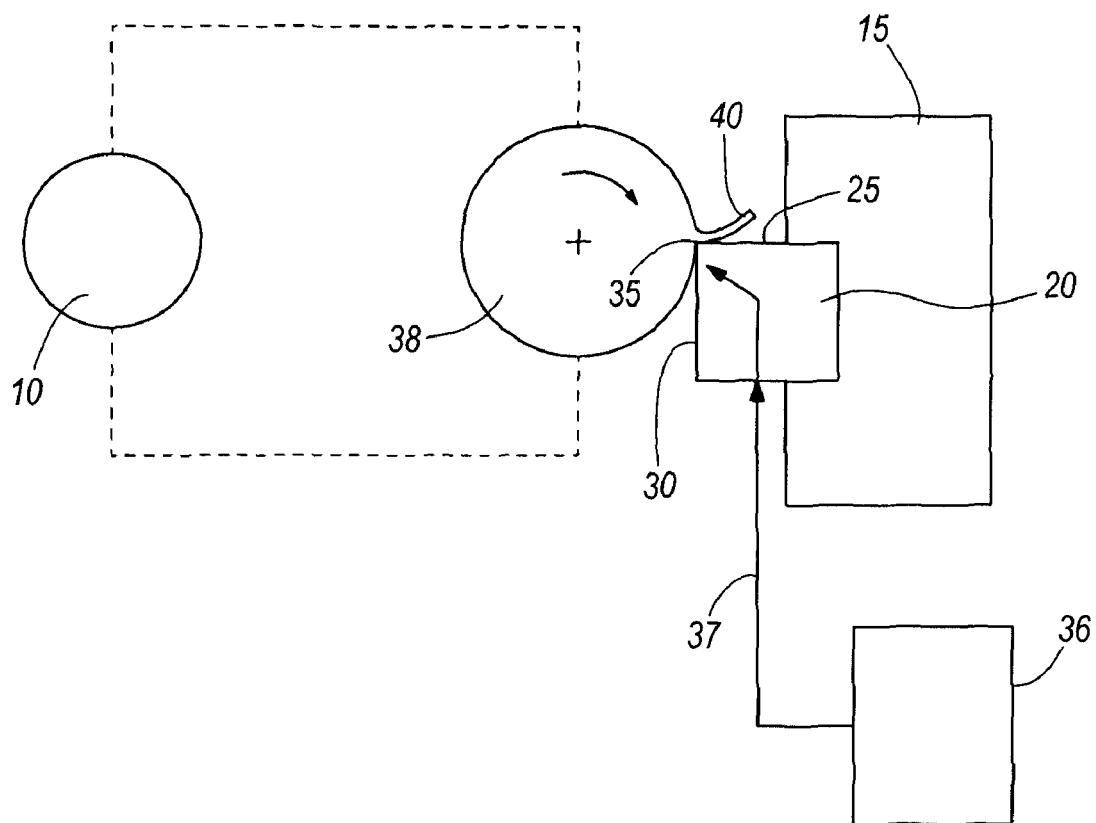
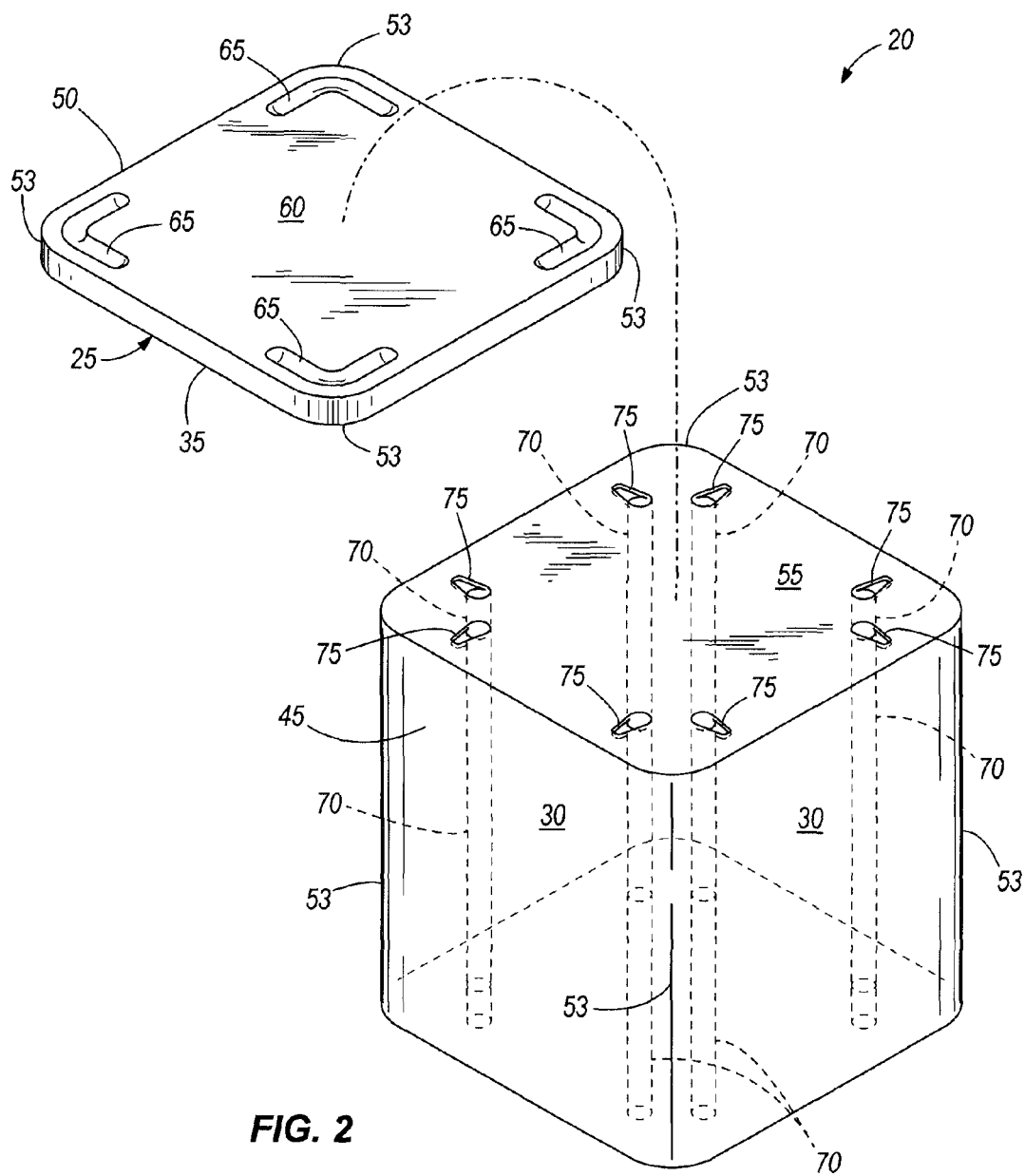
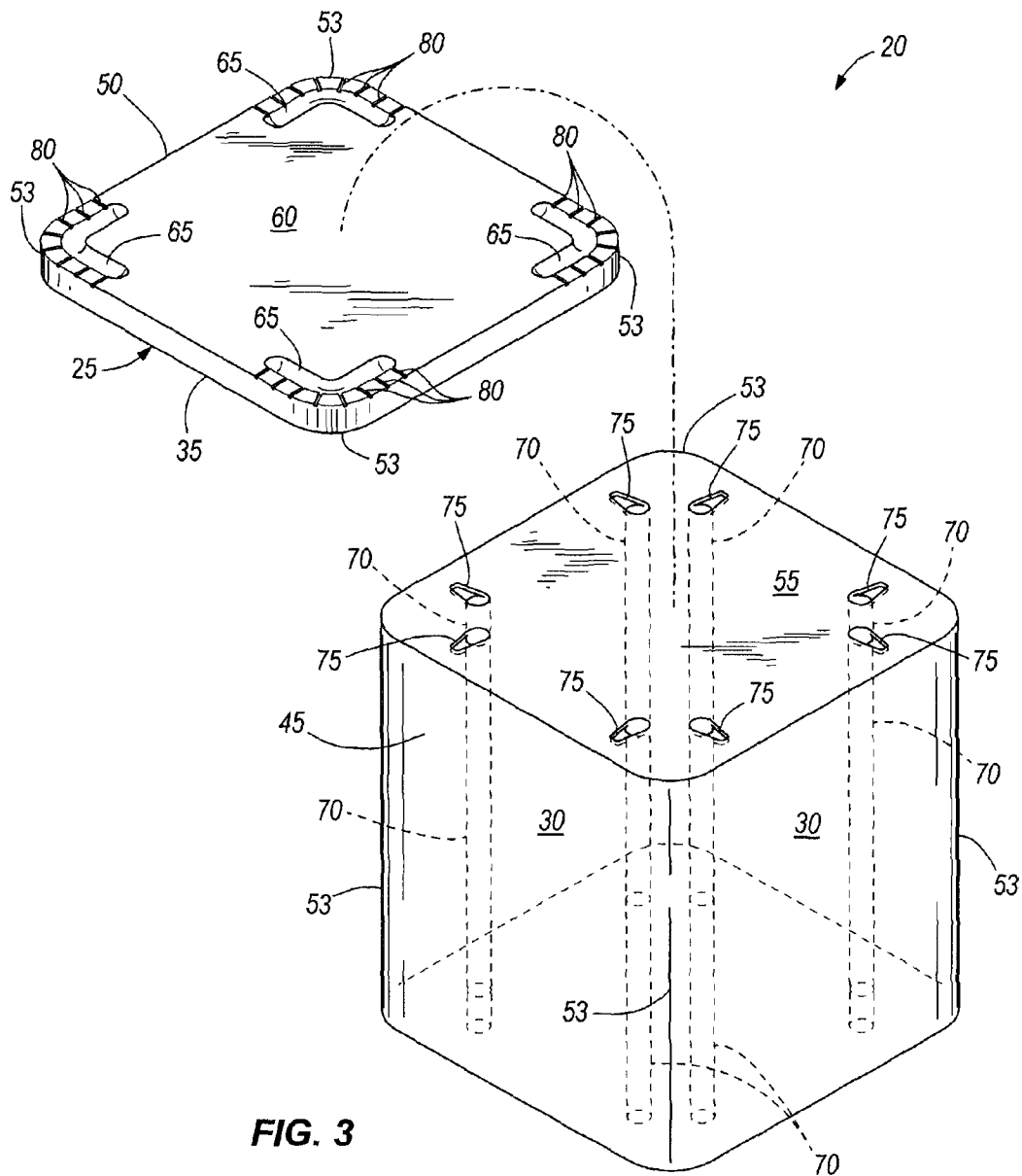


FIG. 1





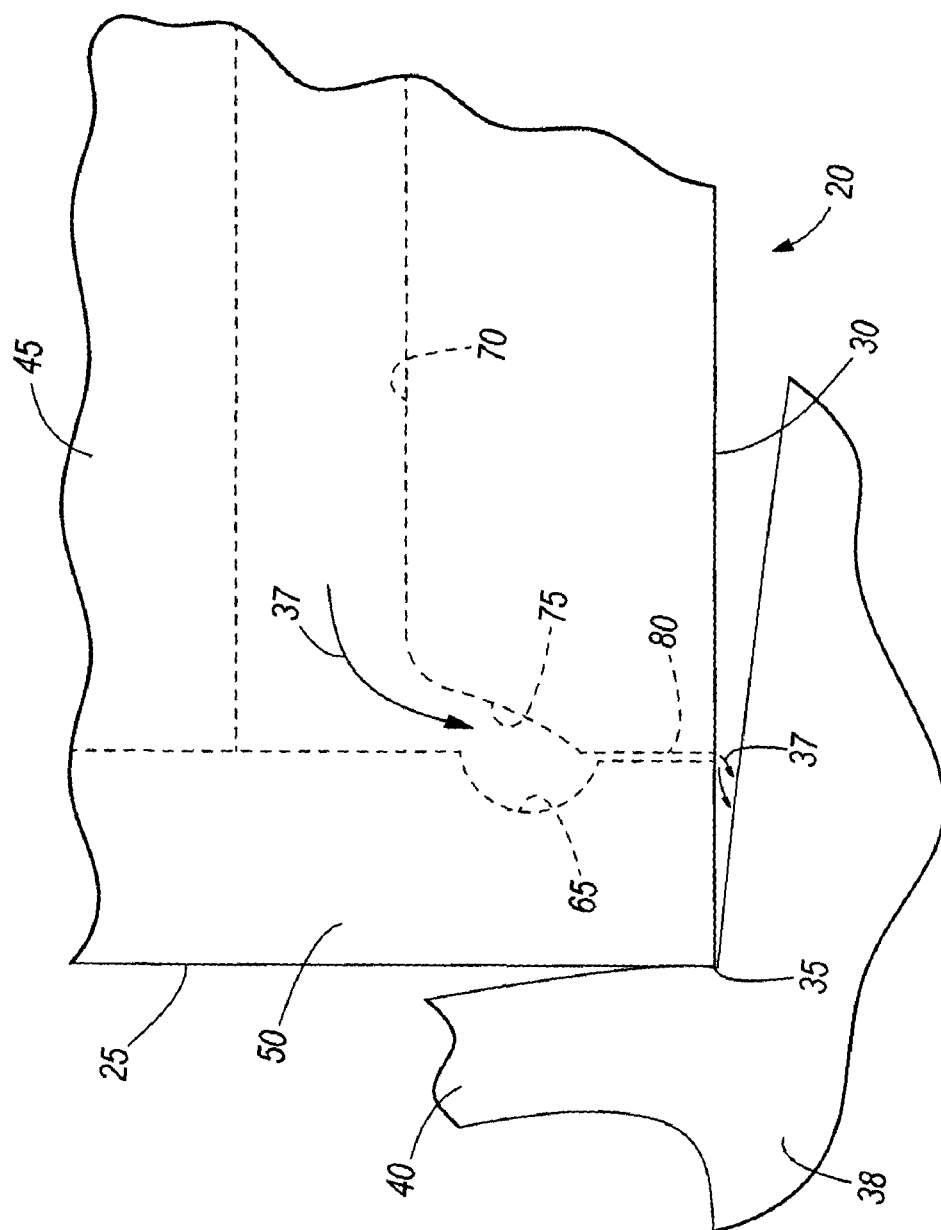


FIG. 4

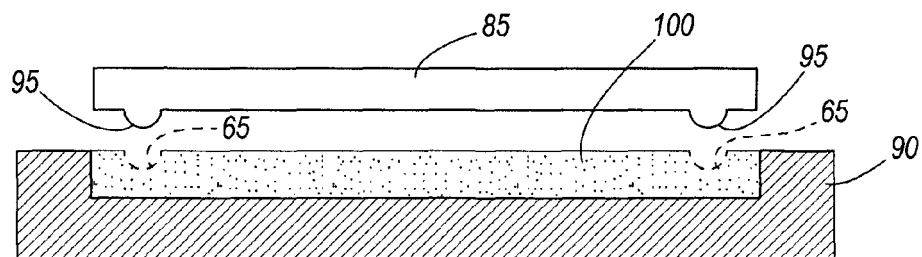


FIG. 5A

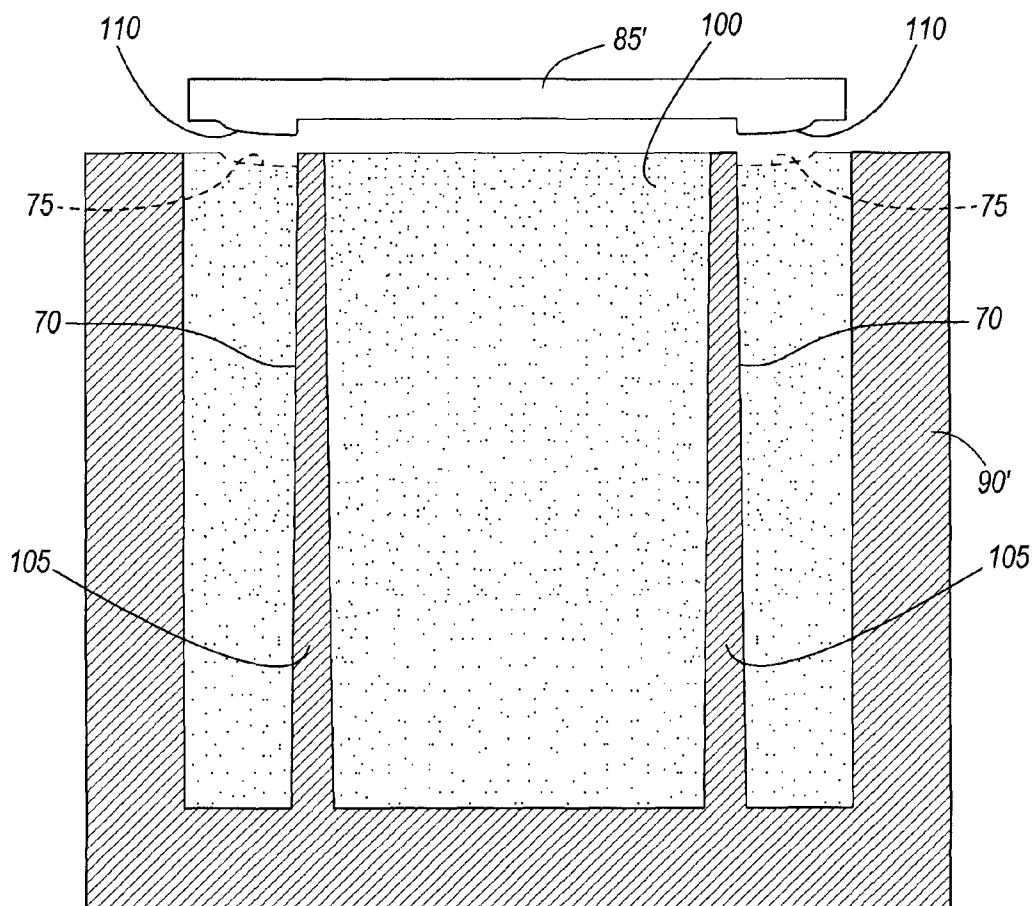


FIG. 5B

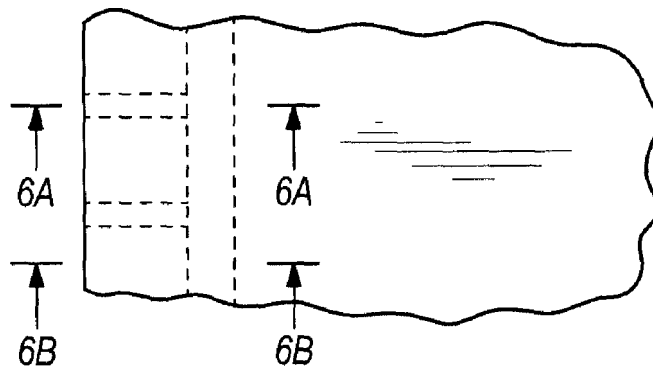


FIG. 6

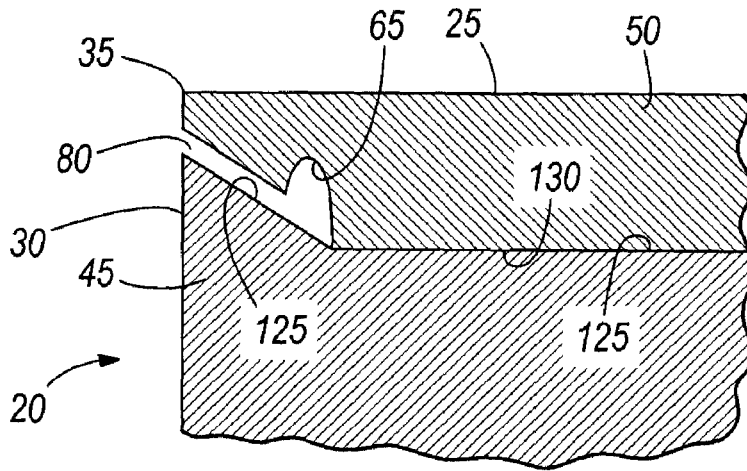


FIG. 6A

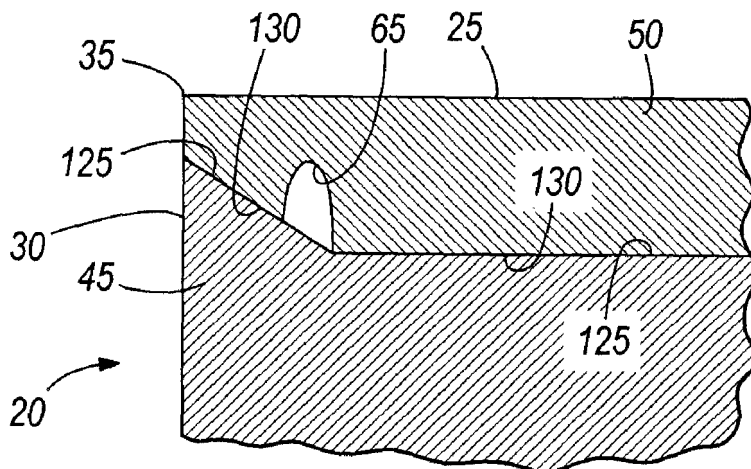
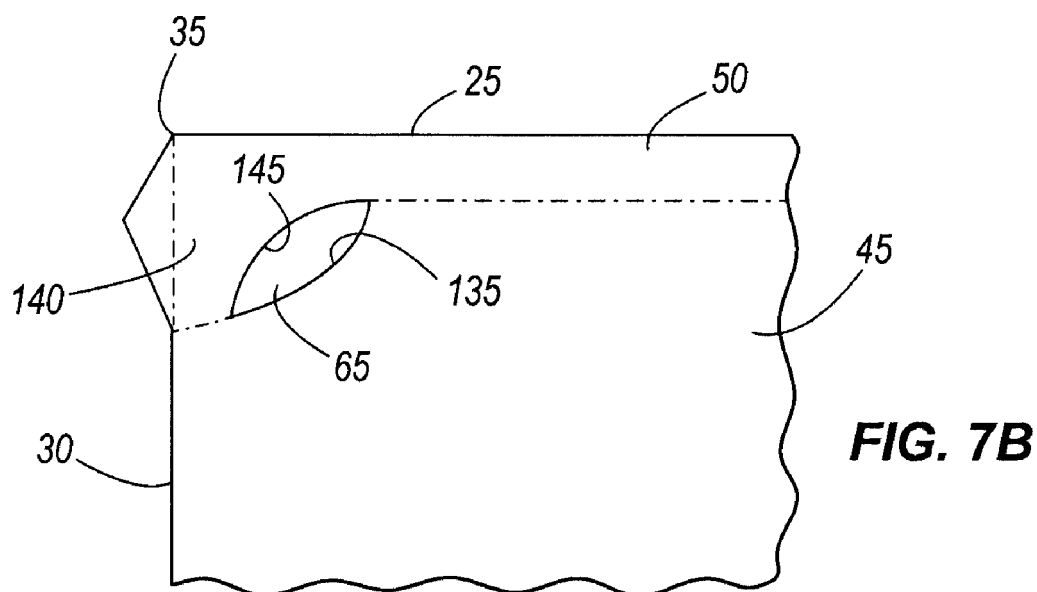
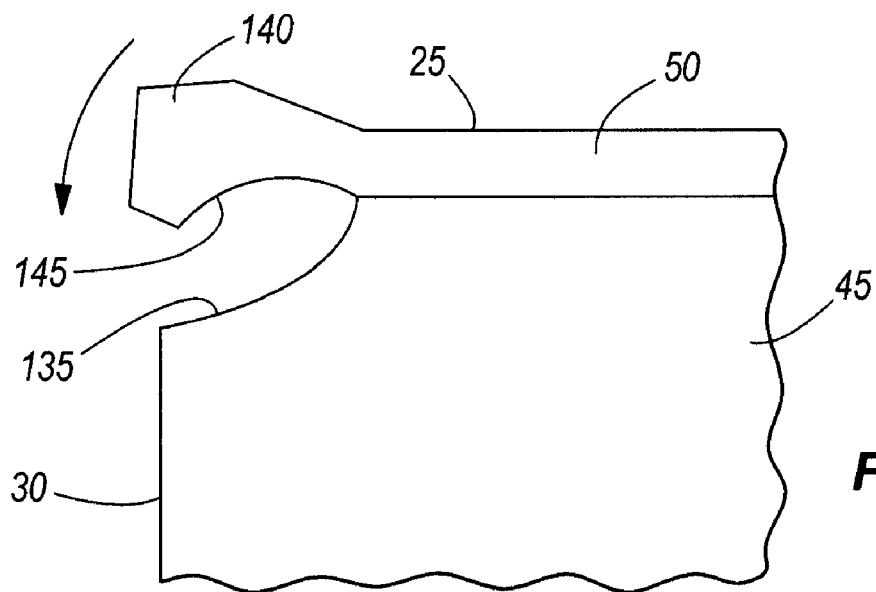


FIG. 6B



CUTTING TOOL INSERT HAVING INTERNAL MICRODUCT FOR COOLANT

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 11/746,186, filed May 9, 2007, now U.S. Pat. No. 7,802,947, issued Sep. 28, 2010

BACKGROUND

The present invention relates to a cutting tool insert having an internal microduct through which coolant flows to transfer heat away from the cutting edge and extend the useful life and productivity of the insert.

The cutting edge of a cutting tool contacts the work piece and performs the actual cutting. While in operation, a large quantity of heat is generated at the cutting edge. Prolonging the life of the cutting tool and operating the cutting tool at high speed requires cooling while the cutting tool is in operation, especially when the cutting tool is used to cut materials such as hardened steel, titanium, and nickel-based high-temperature alloys. A conventional method of cooling includes, for example, "flood" cooling, where a steady stream of coolant is splashed on the work piece and the cutting tool while in operation. This method of cooling is not very effective, as it provides indirect cooling of the cutting tool edge, as it is obstructed by the chip, and requires a relatively complex recycling system to salvage, filter, and reuse the excessive quantities of coolant used.

It is also known to flow a coolant through cooling conduits in a cutting tool insert. However, known assemblies employ conduits having cross-sectional dimensions on the millimeter scale, and require relatively large flow rates of coolant. Because of their relatively large size, such known cooling conduits can only be positioned a certain distance from the rake face, flank face, and cutting edge without affecting the structural strength of the cutting tool insert. Such known cooling microducts are focused on cooling the entire cutting tool insert, rather than focusing on transferring heat away from the cutting edge itself.

SUMMARY

In one embodiment, the invention provides a cutting tool insert comprising: a body defining a rake face, a flank face, and a cutting edge at an intersection of the rake face and flank face; and a cooling microduct within the body, the microduct having a cross-sectional area of not more than 1.0 square millimeter, the microduct being adapted to permit a flow of coolant therethrough to transfer heat away from the cutting edge and extend the useful life of the insert; and an inlet flow passage in the body, at least a portion of the inlet flow passage extending substantially perpendicular to the rake face, the inlet flow passage communicating between the microduct and a source of coolant for the delivery of the flow of coolant to the microduct.

In some embodiments, the microduct communicates through the flank face to exhaust the flow of coolant behind the cutting edge. The microduct may communicate through at least one of the rake face and the flank face to exhaust the flow of coolant from the cutting tool insert. The microduct may include a plurality of microducts communicating through at least one of the rake face and the flank face. The microduct may include a plurality of microducts communicating through at least one of the rake face and the flank face;

wherein at least a portion of each of the plurality of microducts has a cross-sectional area no larger than 0.004 square millimeter.

In another embodiment, the invention provides a method for manufacturing a cutting tool insert, the method comprising: forming a green state first portion having a first mating surface; forming a green state second portion having a second mating surface; forming an open channel into the first mating surface; placing the first and second mating surfaces into contact with each other to cover the open channel to define a microduct having a cross-sectional area no larger than 1.0 square millimeter; metallurgically bonding the first and second portions together to define a cutting tool insert having therein the microduct; and defining on the insert a rake face, a flank face, and a cutting edge at an intersection of the rake face and flank face, such that the microduct communicates through at least one of the rake face and the flank face.

In some embodiments, the step of forming an open channel includes pressing the open channel into the first mating surface. Forming an open channel may include at least one of micro-machining, grinding, and scratching the open channel into the first mating surface. Forming an open channel may include hole-popping by micro-electrical discharge machining. Forming an open channel may include forming a plurality of open channels in the first mating surface; wherein placing the first and second mating surfaces into contact with each other includes covering the plurality of open channels to define a plurality of microducts communicating through at least one of the rake face and the flank face. Forming a plurality of open channels may include forming a plurality of channels each having a portion with a cross-sectional area no larger than 0.004 square millimeter. Metallurgically bonding may include sintering the first and second portions together. The method may further comprise forming a filleted rabbet in the second portion; wherein metallurgically bonding includes applying heat to the first portion and second portion to cause a portion of the second portion to sag against the first portion with the open channel extending across the rabbet, such that the first portion and second portion are metallurgically bonded into a monolithic body with the open channel and rabbet defining therebetween the microduct.

In another embodiment, the invention provides a method for extending the useful life of a cutting tool insert that has a rake face, a flank face, and a cutting edge at an intersection of the rake face and flank face, the method comprising: providing a microduct within the insert, the microduct having a cross-sectional area of not more than 1.0 square millimeter; communicating the microduct through at least one of the rake face and flank face; providing a coolant supply passage in the insert in communication with the microduct; causing a flow of coolant to flow through the supply passage and into the microduct; and causing the flow of coolant to exhaust from the insert through the microduct to transfer heat away from the cutting edge.

The step of causing a flow of coolant to flow may include causing coolant to flow through the microduct at a flow rate no greater than about 0.2 liter per minute. The step of causing a flow of coolant to flow may include moving the flow of coolant with a pump having a power rating no greater than about 1 horsepower. The step of causing a flow of coolant to flow may include moving the flow of coolant with a gravity feed system. The step of causing a flow of coolant to flow may include causing a flow of room temperature water to flow through the supply passage and into the microduct. The step of causing a flow of coolant to flow may include causing a flow of at least one of oil, liquefied gas, compressed gas, and refrigerant to flow through the supply passage and into the

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microduct. The step of providing a microduct may include providing a microduct having at least a portion with a cross-sectional area no larger than 0.004 square millimeter. The of causing the flow of coolant to exhaust may include vaporizing the coolant as the coolant flows out of the microduct.

Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a cutting system including an internal microduct cooled cutting tool insert embodying the present invention.

FIG. 2 is a perspective view of the cutting tool insert being assembled.

FIG. 3 is a perspective view of another embodiment of the cutting tool insert being assembled.

FIG. 4 is an enlarged side view of a portion of the embodiment illustrated in FIG. 3, during a cutting operation.

FIG. 5A is a side cross-sectional view of a mold for forming a wafer portion of the cutting tool insert.

FIG. 5B is a side cross-sectional view of a mold for forming a base portion of the cutting tool insert.

FIG. 6 is a view of a portion of another embodiment of the cutting tool insert.

FIG. 6A is a cross-sectional view taken along line 6A-6A in FIG. 6.

FIG. 6B is a cross-sectional view taken along line 6B-6B in FIG. 6.

FIG. 7A is a side view of a portion of another embodiment of the cutting tool insert during assembly.

FIG. 7B is another side view of a portion of the embodiment of the cutting tool insert illustrated in FIG. 7B during assembly.

DETAILED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

The present invention involves very small scale ducting in a cutting tool insert. For the sake of illustration, the drawings are not drawn to scale.

FIG. 1 illustrates a system that includes a prime mover 10 (e.g., a motor), a holder 15, and a cutting tool insert 20 in the holder 15. The cutting tool insert 20 includes a rake face 25, a clearance or flank face 30, and a cutting edge 35 at the intersection of the rake and flank faces 25, 30. The system also includes a source of coolant 36 providing coolant 37 to the insert 20. Mounted in the system is a work piece 38 that is, in the illustrated embodiment, rotated under the influence of the

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prime mover 10. The insert 20 cuts a chip 40 from the work piece 38 when brought into contact with the work piece 38 or when the work piece 38 is brought into contact with the insert 20. It is envisioned that the insert 20 could be incorporated into a lathe, a mill, a planar, a drill, or any other machine in which stationary or rotational cutting tools are utilized.

With reference to FIG. 2, the insert 20 is constructed from a base 45 and a wafer 50. The base and wafer 45, 50 include radiused corners 53. The surface of the wafer 50 facing down in FIG. 2 forms the rake face 25 of the insert 20, and the edge along the perimeter of the rake face 25 forms the cutting edge 35 of the insert 20. Once the insert 20 is assembled, the four sides of the base 45 and wafer 50 together form the flank faces 30. The base 45 and wafer 50 have mating surfaces 55, 60, respectively, that abut against each other when the insert 20 is assembled.

The insert 20 can be used to cut with the portion of the cutting edge 35 along each of the four radiused corners 53, with one side or the other of the radiused corner 53 performing most of the work depending on whether the insert 20 is used in a right-handed or left-handed cutting operation. When the edge 35 along one corner 53 is worn down, the insert 20 can be indexed ninety degrees so that the edge 35 along the next corner 53 can be used. Consequently, the insert 20 can be used four times before it needs to be replaced. In other embodiments, the cutting edge 35 may define a straight line (rather than the illustrated radiused corners).

Formed in the mating surface 60 of the wafer 50 along each of the four radiused corners 53 is an open channel that defines a microduct 65. Extending up from the bottom of the insert 20 generally perpendicular to the rake face 25 and parallel to the flank faces 30 are eight flow passages 70 (a pair near each of the radiused corners 53). The flow passages 70 are sized to receive a standard hose or other conduit fitting to facilitate the flow of coolant 37 into the insert 20. Formed in the mating face 55 of the base 45 are open channels that define eight connecting passages 75, each communicating at one end with an associated flow passage 70.

The base 45 and wafer 50 may be provided, for example, as green-state parts suitable for sintering (the construction of which is discussed below). During assembly, the wafer 50 is placed over the end of the base 45. The open channels forming the microducts 65 are consequently closed by the mating surface 55 of the base 45, and the open channels forming the connecting passages 75 are closed by the mating surface 60 in the wafer 50, such that the microducts 65 and connecting passages 75 are now closed conduits inside the insert 20.

When the base and wafer 45, 50 are properly aligned, the connecting passages 75 communicate between the associated flow passage 70 and an end of an associated microduct 65. The flow passages 70 are substantially larger in cross-section than the microducts 65, and the connecting passages 75 are therefore tapered from a large end communicating with the flow passage 70 to a small end communicating with the microduct 65. The connecting passages 75 act as funnels in this regard. Four coolant flow circuits, each comprising two flow passages 70, two connecting passages 75, and one microduct 65 in fluid communication are therefore created when the wafer 50 is properly positioned on the base 45.

Once properly aligned, the green-state base 45 and wafer 50 are joined by sintering. More specifically, heat is applied to the assembly to metallurgically bond the base 45 and wafer 50 into a unitary, integral, non-separable cutting tool insert 20 having the above-mentioned coolant flow circuits. After sintering, the rake and flank faces 25, 30 may be machined to provide a sharp cutting edge 35. Removing material from the rake and flank faces 25, 30 via machining also effectively

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moves the microducts **65** closer to those faces **25**, **30** and to the cutting edge **35**. Machining will therefore permit the microducts **65** to be positioned a desired distance away from the cutting edge **35**, rake face **25**, and flank face **30**.

In the embodiment illustrated in FIG. 2, the microduct **65** is formed in the wafer **50**. It will be recognized that the microduct **65** may be formed in either the base **45** or wafer **50**, or may be partially formed in each of the base **45** and wafer **50**. It is also contemplated by the present invention that the connecting passage **75** may be formed in either or both of the base **45** and wafer **50** so long as fluid communication through the insert **20** is established.

As used herein, "microduct" means a duct having a cross-sectional area of not more than 1.0 square millimeter. In some embodiments, the cross-sectional area may be about 0.07 square millimeter, 0.05 square millimeter, 0.035 square millimeter, or even as small as about 0.025 square millimeter. The microducts may have circular cross-sections with diameters in the range of 250-300 micrometers (0.250-0.300 millimeter), or semi-circular cross-sections (as illustrated) with radii in the range of 125-150 micrometers (0.125-0.150 millimeter), for example. Other cross-sectional shapes are possible for the microduct, such as, for example, squares, rectangles, ovals, hexagons, and other shapes, including irregular shapes. By way of comparison, known "milliducts" used in cutting tool inserts have cross-sectional areas in the range of 1.0-7.0 square millimeters, and may therefore be multiple times larger than the microducts contemplated by the present invention.

The very small size of the microduct **65** permits it to be positioned much closer to the cutting edge **35**, rake face **25**, and flank face **30** than is possible for known milliducts, while not substantially decreasing the strength of the cutting tool insert **20**. For example, the size of a microduct permits it to be positioned within about 100-150 micrometers (0.100-0.150 millimeter) from both the rake face **25** and flank face **30**. Because of the close proximity of the microduct **65** to the cutting edge **35**, heat is transferred more efficiently from the cutting edge **35** to coolant **37** flowing through the microduct **65** than when known milliducts are used. In this regard, the present invention focuses on cooling the cutting edge **35** specifically and not the insert **20** generally.

Because of the increased efficiency in heat transfer, less coolant **37** is required to maintain the cutting edge **35** within a desired range of operating temperatures than would be required for known tools employing milliducts or flood cooling. Because of the small volumes of coolant **37** used in present invention, it will in most cases not be necessary to recycle coolant **37** to achieve system efficiencies (although depending on the coolant **37**, it may be desirable to collect, contain or recycle for other reasons). By way of example, but without limitation, some coolants **37** that may be suitable for use in the present invention are water (tap water at room temperature, for example), oil, liquefied gas, compressed gas, and refrigerant.

For example, the useful life of a cutting tool insert can be increased by flowing room-temperature tap water through a microduct **65** at rates as low as about 0.1-0.2 liter per minute (about 0.025-0.05 gallon per minute). Such flow rates can be achieved with a pump having a power rating of significantly less than 1 horsepower, or even with a gravity feed system having sufficient head pressure.

Referring again to the embodiment illustrated in FIG. 2, one of the two flow passages **70** (depending whether the insert **20** is being used in a right-handed or left-handed cutting operation) receives coolant **37** from the source **36**, and this flow passage **70** may be termed an inlet flow passage. The

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coolant **37** flows into one end of the microduct **65** via one of the connecting passages **75** and through the microduct **65**. The coolant then exits the insert **20** via the connecting passage **75** and the flow passage **70** at the other end of the microduct **65**, such that the other flow passage **70** may be termed an exhaust flow passage. When the insert **20** is indexed to cut with a new radiused corner **53**, the coolant supply hose is plugged into one of the flow passages in the coolant flow circuit associated with the new corner.

FIG. 3 illustrates a variation (referred to as "primary-secondary") on the embodiment illustrated in FIG. 2, in which secondary microducts **80** communicate between the primary microducts **65** and the flank faces **30** of the insert **20**. The insert **20** in FIG. 3 is in all other respects substantially similar to that discussed above with reference to FIG. 2.

The secondary microducts **80** may be formed in either the base **45** or wafer **50** while pressing the green-state wafer **50** or by scratching the base **45** or wafer **50** with a rake having tines of sufficiently thin gauge to result in the secondary microducts **80**. Again, because of the extremely small size of the secondary microducts **80**, they are not illustrated to scale, but the secondary microducts **80** are of even smaller cross-sectional area than the microduct **65**. For example, the secondary microducts **80** may be semicircular in cross-section and have radii in the range of 25-50 micrometers (0.025-0.050 millimeter). The cross-sectional area of the secondary microducts **80** may therefore be in the range of about 0.001-0.004 square millimeter.

The primary-secondary embodiment relies primarily upon the secondary microducts **80** to cool the cutting edge **35**, and consequently the primary microduct **65** can be moved further away from the rake face **25**, flank face **30**, and cutting edge **35**. For example, in one primary-secondary embodiment, the secondary microducts **65** may be 500 micrometers (0.500 millimeter) or further from the rake face **25** and flank face **30**. Because the coolant **37** in this embodiment is intended to flow out the secondary microducts **80**, one of the two flow passages **70** (depending whether the insert **20** is being used in a right-handed or left-handed cutting operation) receives coolant **37** from the source **36**, and the other is plugged or blocked. This establishes the primary microduct **65** as a manifold with substantially constant pressure along its length. The coolant **37** consequently flows substantially equally into the secondary microducts **80**. The secondary microducts **80** can therefore be referred to as exhaust conduits in this embodiment.

As illustrated in FIG. 4, the coolant **37** flows out of the secondary microducts **80** slightly behind the cutting edge **35** of the insert **20**. As used herein, the term "behind the cutting edge" means through the flank face **30** of the insert **20**, into the space between the flank face **30** and the work piece **38**. While the secondary microducts **80** may in other embodiments extend through the rake face **25** and vent or exhaust the coolant **37** above the cutting edge **35**, such secondary microducts **80** may be partially or entirely blocked by the chip **40**.

The secondary microducts **80** act as nozzles for the coolant **37** being exhausted or vented from the insert **20**. The coolant **37** pressure drops as it exits the secondary microducts **80** and quickly expands to atmospheric pressure. Depending on the pressure drop and type of coolant, the coolant **37** may vaporize as it exhausts, and such vaporization will be accompanied by a large temperature drop that will further cool the cutting edge **35** in particular. Depending on its properties and the conditions, a coolant **37** may completely or partially vaporize in the microducts **65**, **80** or may not vaporize at all.

FIG. 5A illustrates an exemplary basic mold setup for creating the wafer **50** of the insert **20**. The setup includes a punch **85** and a die **90**. The illustrated punch and die **85**, **90** are

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used to create an insert **20** such as that illustrated in FIG. 2, which includes multiple microducts **65**, and so the punch **85** includes multiple ribs **95** that are each of the proper size and shape to form an impression of a microduct **65**.

The die **90** contains a sintering material **100**, and the punch **85** compresses the sintering material **100** in the die **90** to form a green-state version of the wafer **50** with the microducts **65** imprinted therein. Wax or another binding agent may be mixed with the sintering material **100** to help hold the green-state wafer **50** together. The sintering material **100** may be any material having suitable material properties for a cutting tool insert, including by way of example and without limitation, carbide, high speed steel, and other tool-grade metals (e.g. steel alloys including at least one of molybdenum, chromium, tungsten, vanadium, cobalt, and carbon).

FIG. 5B illustrates a setup for creating the base portion **45** of the insert **20**. The setup illustrated in FIG. 5B includes a punch **85'** and a die **90'** containing similar sintering material **100** (with wax or other binding agent mixed in) as described above. The die **90'** includes multiple projections **105** to form the multiple flow passages **70** in the embodiment illustrated in FIG. 2, and the punch **85'** includes multiple projections **105** to form the multiple connecting passages **75**. A green-state version of the base portion **45** of the insert **20** is formed when the punch **85'** is pressed into the sintering material **100** in the die **90'**, and the projections and ribs **105**, **110** define the flow passages **70** and connecting passages **75**.

It will be understood by one of ordinary skill in the art that the presses **85**, **85'** may be modified in the event the microduct **65** is intended to be formed in the base portion **45** by removing the ribs **95** from the punch **85** for the wafer **50** and including the ribs **95** in the punch **85'** for the base **45**. For embodiments in which the microducts **65** are partially formed in the wafer **50** and partially formed in the base **45** (as in the embodiment described with respect to FIGS. 7A and 7B below), a modified version of the ribs **95** may be included in both presses **85**, **85'** for such purpose. Also, the connecting passages **75** may be formed in the wafer **50** (regardless of whether the microduct **65** is formed in the base **45** or wafer **50**) by including the rib **110** in the punch **85** for the wafer **50**. Either or both of the presses **85**, **85'** may also be further modified to include ribs for the purpose of creating the secondary microducts **80** in the base **45** and/or wafer **50**. It will also be understood that in other embodiments, the peripheral walls of the dies **90**, **90'** may be fixed or stationary, the bottom surface of each die **90**, **90'** may be a movable punch (for ejecting the green-state version of the base **45** or wafer **50**), and the projections **105** may be fixed or stationary cores or core pins.

FIGS. 6, 6A, and 6B illustrate a variation on the insert **20** in which the base **45** and wafer **50** have mating surfaces **125**, **130** that are non-planar (unlike the generally planar mating surfaces **55**, **60** in the constructions illustrated in FIGS. 2 and 3) to ensure proper alignment by causing the wafer **50** and base **45** to nest together. The nesting relationship keeps the wafer **50** and base **45** aligned before and during the sintering process. It is also envisioned that this nesting relationship could be employed in all other embodiments described herein. The illustrated secondary microducts **80** extend along the mating surface **125** of the base **45** at an angle that causes the venting or exhaust end of the secondary microducts **80** to be even closer to the cutting edge **55**. While the illustrated insert **20** in FIGS. 6, 6A, and 6B includes the microduct **65** and secondary microducts **80** in the wafer **50**, it is to be understood that the non-planar mating surfaces **125**, **130** may be used in embodiments in which the microduct **65** and/or secondary ducts **80** are formed in the base **45** or in which no secondary ducts **80** are provided.

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FIGS. 7A and 7B show another method of manufacturing the insert **20** in which the punch used to form the base **45** creates a filleted rabbet **135**, and in which the wafer **50** is formed with an end **140** that defines a curved open channel **145**. The wafer **50** is placed on the base **45** as illustrated in FIG. 7A, and when heat is applied, the end **140** of the wafer **50** sags down such that the curved open channel **145** extends across the rabbet **135** and the end **140** contacts the base **45**, as illustrated in FIG. 7B. The result is that the rabbet **135** and channel **145** define the microduct **65**. Any extra material along the end **140** of the wafer **50** can then be machined off to define the cutting edge **35**. Secondary microducts **80** may be provided in this embodiment by scratching the edge of the rabbet **135** or the end **140** or incorporating ribs in the punch and/or die for that purpose.

Although the use of pressing to create green-state wafer **50** and base **45**, followed by sintering has been discussed as a method for manufacturing the insert **20**, the coolant flow circuits can in other embodiments be formed by a variety of other processes that have not been illustrated. For example, microducts could be micro-machined or ground into the green-state wafer **50**, green-state base **45**, or into a one-piece cutting tool insert that does not require the wafer and base components. Machined ducts would in most cases have a generally square cross-section. In other embodiments, the microducts may be formed by "hole-popping" such as micro-electrical discharge machining, or micro-EDM.

Various features and advantages of the invention are set forth in the following claims.

The invention claimed is:

1. A cutting tool insert comprising:

a body defining a rake face, a flank face, and a cutting edge at an intersection of the rake face and flank face; and a cooling microduct within the body, the microduct having a cross-sectional area of not more than 1.0 square millimeter, the microduct being adapted to permit a flow of coolant therethrough to transfer heat away from the cutting edge and extend the useful life of the insert; and an inlet flow passage in the body, at least a portion of the inlet flow passage extending substantially perpendicular to the rake face, the inlet flow passage communicating between the microduct and a source of coolant for the delivery of the flow of coolant to the microduct.

2. The cutting tool insert of claim 1, wherein the microduct communicates through the flank face to exhaust the flow of coolant behind the cutting edge.

3. The cutting tool insert of claim 1, wherein the microduct communicates through at least one of the rake face and the flank face to exhaust the flow of coolant from the cutting tool insert.

4. The cutting tool insert of claim 1, wherein the microduct includes a plurality of microducts communicating through at least one of the rake face and the flank face.

5. The cutting tool insert of claim 1, wherein the microduct includes a plurality of microducts communicating through at least one of the rake face and the flank face; and wherein at least a portion of each of the plurality of microducts has a cross-sectional area no larger than 0.004 square millimeter.

6. A method for manufacturing a cutting tool insert, the method comprising:

forming a green state first portion having a first mating surface;
forming a green state second portion having a second mating surface;
forming an open channel into the first mating surface;

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placing the first and second mating surfaces into contact with each other to cover the open channel to define a microduct having a cross-sectional area no larger than 1.0 square millimeter;

metallurgically bonding the first and second portions together to define a cutting tool insert having therein the microduct; and

defining on the insert a rake face, a flank face, and a cutting edge at an intersection of the rake face and flank face, such that the microduct communicates through at least one of the rake face and the flank face.

7. The method of claim 6, wherein the step of forming an open channel includes pressing the open channel into the first mating surface.

8. The method of claim 6, wherein forming an open channel includes at least one of micro-machining, grinding, and scratching the open channel into the first mating surface.

9. The method of claim 6, wherein forming an open channel includes hole-popping by micro-electrical discharge machining.

10. The method of claim 6, wherein the step of forming an open channel includes forming a plurality of open channels in the first mating surface; wherein placing the first and second mating surfaces into contact with each other includes covering the plurality of open channels to define a plurality of microducts communicating through at least one of the rake face and the flank face.

11. The method of claim 10, wherein forming a plurality of open channels includes forming a plurality of channels each having a portion with a cross-sectional area no larger than 0.004 square millimeter.

12. The method of claim 6, wherein metallurgically bonding includes sintering the first and second portions together.

13. The method of claim 6, further comprising forming a filleted rabbet in the second portion; wherein metallurgically bonding includes applying heat to the first portion and second portion to cause a portion of the second portion to sag against the first portion with the open channel extending across the rabbet, such that the first portion and second portion are metallurgically bonded into a monolithic body with the open channel and rabbet defining therebetween the microduct.

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14. A method for extending the useful life of a cutting tool insert that has a rake face, a flank face, and a cutting edge at an intersection of the rake face and flank face, the method comprising:

providing a microduct within the insert, the microduct having a cross-sectional area of not more than 1.0 square millimeter;

communicating the microduct through at least one of the rake face and flank face;

providing a coolant supply passage in the insert in communication with the microduct;

causing a flow of coolant to flow through the supply passage and into the microduct; and

causing the flow of coolant to exhaust from the insert through the microduct to transfer heat away from the cutting edge.

15. The method of claim 14, wherein the step of causing a flow of coolant to flow includes causing coolant to flow through the microduct at a flow rate no greater than about 0.2 liter per minute.

16. The method of claim 14, wherein the step of causing a flow of coolant to flow includes moving the flow of coolant with a pump having a power rating no greater than about 1 horsepower.

17. The method of claim 14, wherein the step of causing a flow of coolant to flow includes moving the flow of coolant with a gravity feed system.

18. The method of claim 14, wherein the step of causing a flow of coolant to flow includes causing a flow of room temperature water to flow through the supply passage and into the microduct.

19. The method of claim 14, wherein the step of causing a flow of coolant to flow includes causing a flow of at least one of oil, liquefied gas, compressed gas, and refrigerant to flow through the supply passage and into the microduct.

20. The method of claim 14, wherein the step of providing a microduct includes providing a microduct having at least a portion with a cross-sectional area no larger than 0.004 square millimeter.

21. The method of claim 14, wherein the step of causing the flow of coolant to exhaust includes vaporizing the coolant as the coolant flows out of the microduct.

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