Rapid Tooling (RT)

HP

Topics

- **Indirect Rapid Tooling**
  - Silicone Rubber Tooling
  - Aluminium filled epoxy tooling
  - Spray metal tooling
  - Cast kirksite
  - 3D keltool
- **Direct Rapid Tooling**
  - Direct AIM

What is RT?

The term *Rapid Tooling* (RT) is typically used to describe a process which either uses a Rapid Prototyping (RP) model as a pattern to create a mould quickly or uses the Rapid Prototyping process directly to fabricate a tool for a limited volume of prototypes

What is RT?

- **Making tools using RP process to**

✓ ***Minimize the cost***

✓ ***Increase the productivity***

✓ ***Increase dimensional accuracy***

✓***Decrease total time***

How is it different from conventional tooling?

- Tooling time is much shorter than for a conventional tool. (almost below one-fifth that of conventional tooling)
- Tooling cost is much less than for a conventional tool. (Cost can be below five percent of conventional tooling cost).
- Tool life is considerably less than for a conventional tool.
- Tolerances are wider than for a conventional tool.

Types of RT

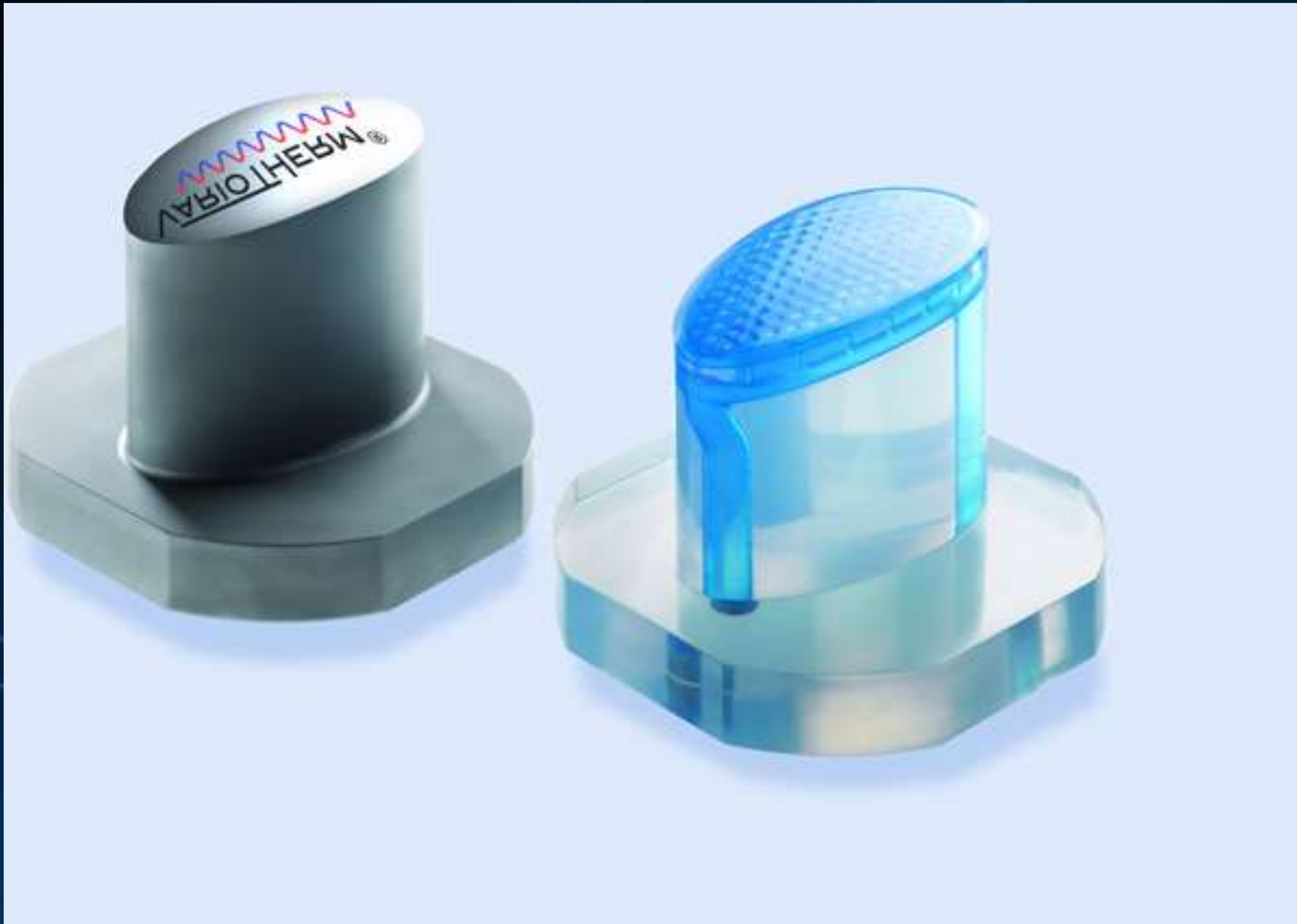
Rapid Tooling can be broadly classified as:

1. ***Indirect Tooling***
2. ***Direct Tooling***

- **Indirect tooling methods used RP inserts to produce moulds**
- **But direct RT methods allow injection moulding and die-casting inserts to build directly from 3D CAD models**

- Rapid Tooling(RT)
  - Indirect RT
  - Direct RT

- ***Indirect or Pattern-based Tooling*** **approaches use master patterns to produce a mould or die, and *Direct Tooling*, where the additive process builds the actual moulds.**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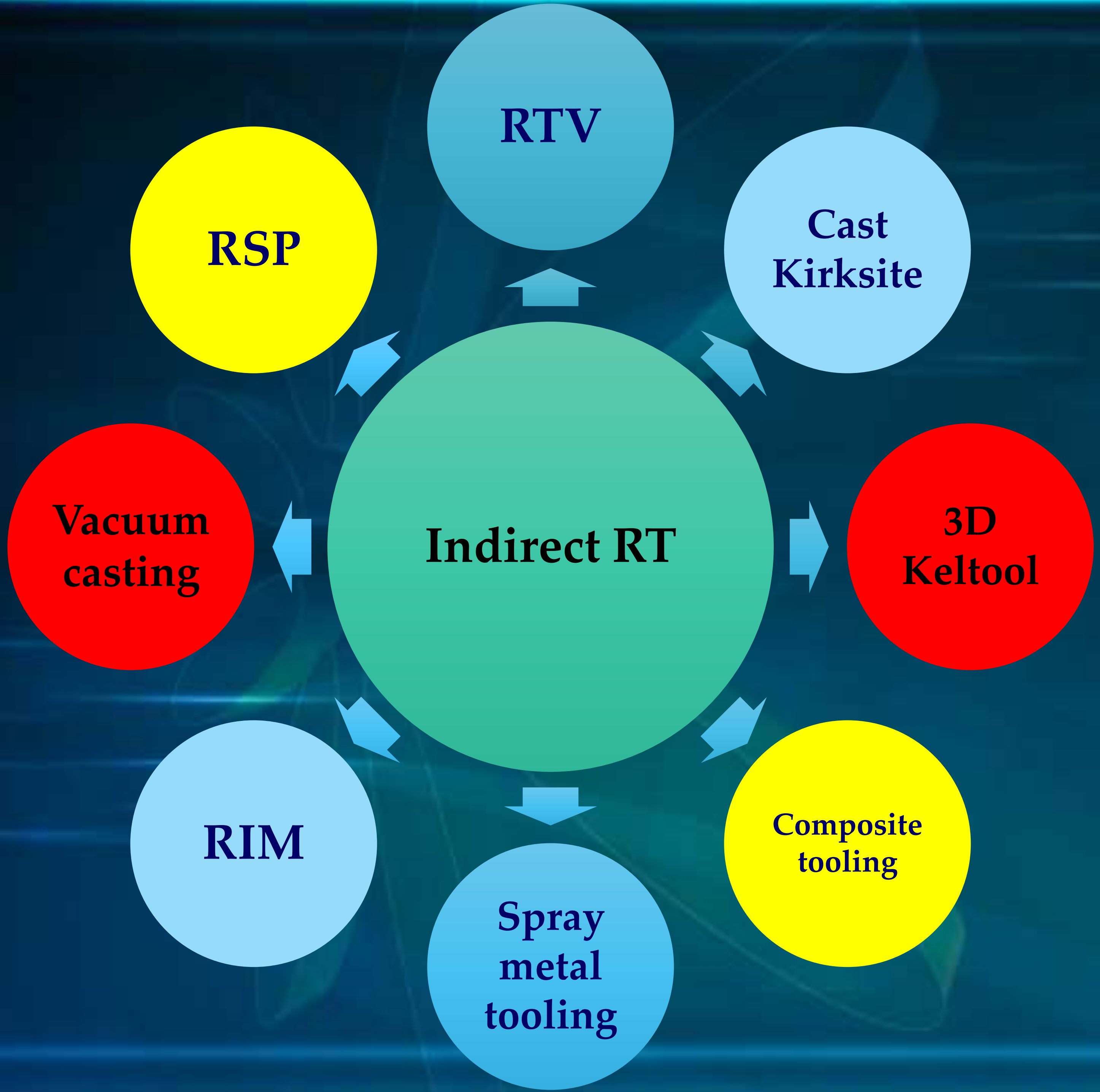
Indirect Tooling (Pattern Based Tooling)

- **Indirect tooling methods are intended as prototyping or pre-production tooling processes and not production methods.**
- **Most any rapid prototyping process can yield patterns for indirect tooling.**


Indirect RT
RTV
Cast Kirksite
3D Keltool
Composite tooling
Spray metal tooling
RIM
Vacuum casting
RSP

Techniques for Indirect RT

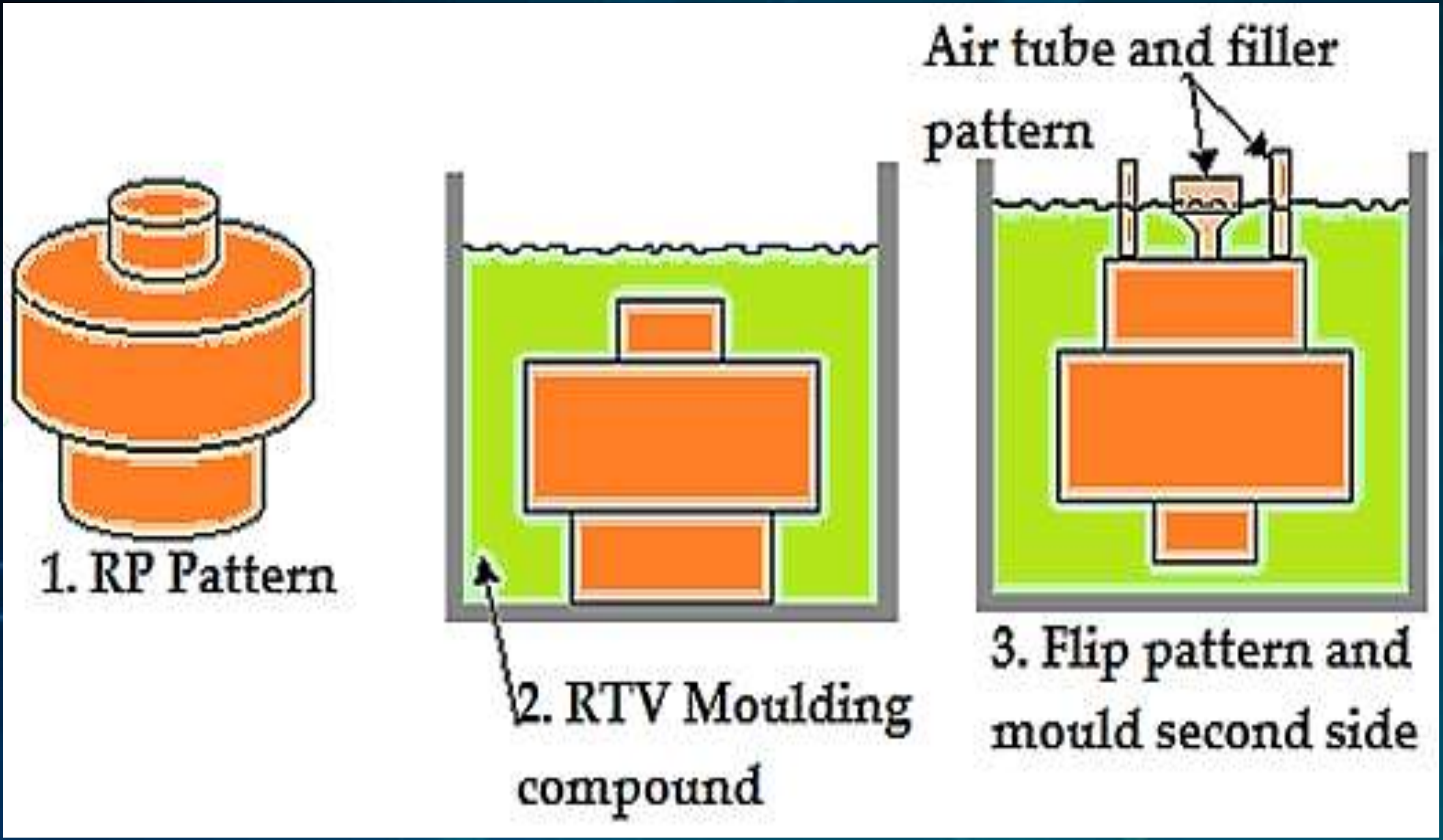
1) RSP Tooling
2) Reconfigurable Tooling
3) Silicone Rubber Tooling
4) Aluminum filled Epoxy Tooling
5) Spray Metal Tooling
6) Cast kirksite
7) 3D Keltool
8) RIM

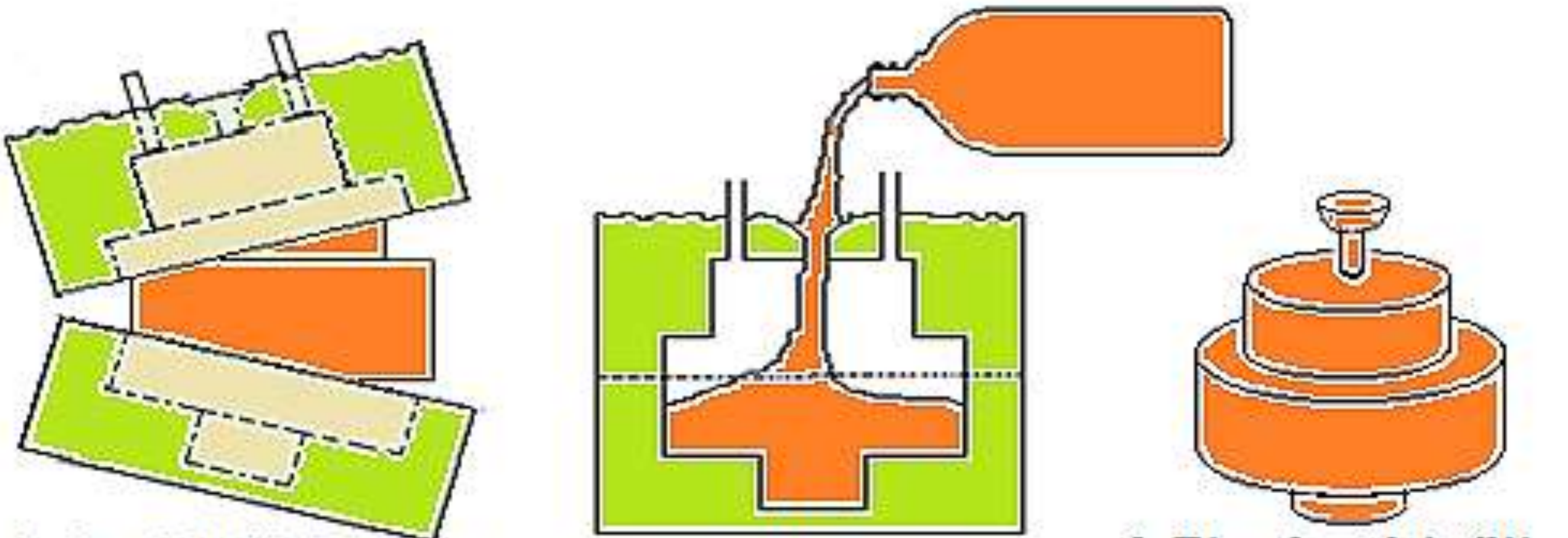
Silicone Rubber Tooling

- One of the most popular tooling applications for RP is the production of room temperature vulcanizing (RTV) silicone rubber tooling
- The purpose of RTV tools is to create urethane or epoxy prototypes, often under vacuum (hence the term vacuum casting)

The process of making a rubber mould consists of:

- Making a master pattern, usually on an RP machine.
- Finishing the pattern to the desired appearance.
- Casting RTV silicone rubber around the pattern to form the mould, and then injecting the mould with two-part thermoset materials to create moulded plastic parts.


Air tube and filler
pattern
1. RP Pattern
2. RTV Moulding
compound
3. Flip pattern and
mould second side



4. Cut RTV Pattern along parting line and remove pattern

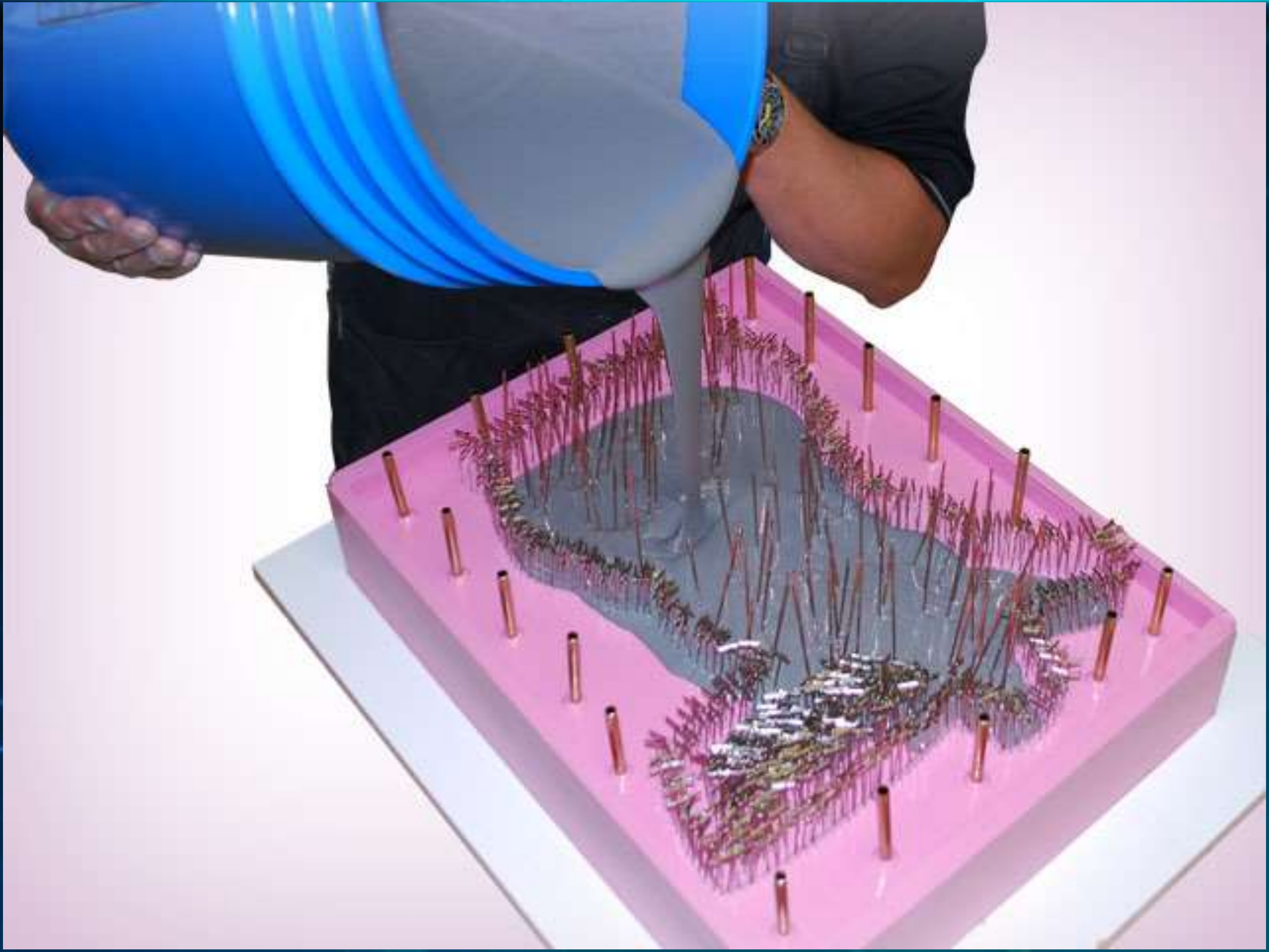
5. Mould Urethane or other plastic

6. Plastic with filler to be removed

- **Silicone rubber tooling provides fast, inexpensive moulds, excellent part cosmetics, and the option of using multiple materials**
- **The process is suitable for small or medium-sized parts**
- **Another benefit of silicone rubber tooling is the negative draft (undercuts) that can be achieved due to the flexibility of the mould material**

Aluminium filled epoxy tooling

- Its also known as 'Composite Tooling'
- Like silicone rubber tooling, epoxy-based composite tooling requires a master pattern
- This pattern is created by RP process
- The pattern is finished and then embedded in a parting line block to create the parting line of the mould



Aluminum filled epoxy tooling

- **Metal inserts are placed in areas where the epoxy is unlikely to withstand the pressures of the injection-moulding process.**
- **Epoxy is then cast against the pattern and parting line block combination to create the first side of the tool.**
- **Once the epoxy has cured, the assembly is inverted, and the parting line is removed, leaving the pattern embedded in the first side of the tool.**
- **The second side of the tool is then cast against the first.**

Time:

- **Composite tooling generates injection moulded parts in 2 to 6 weeks**

Production Rate:

- **The moulding process will have a cycle time of 5 to 15 minutes**

Accuracy

- **Accuracy is dependent on the SLA model. Typically about +/-0.005" to +/-0.015"**

Cost

- **Dependent upon the cost of the master pattern, and overall size of the part. An SLA master pattern can cost between $300 to $1000, on average, and the epoxy tool is typically between $800 and $1000**

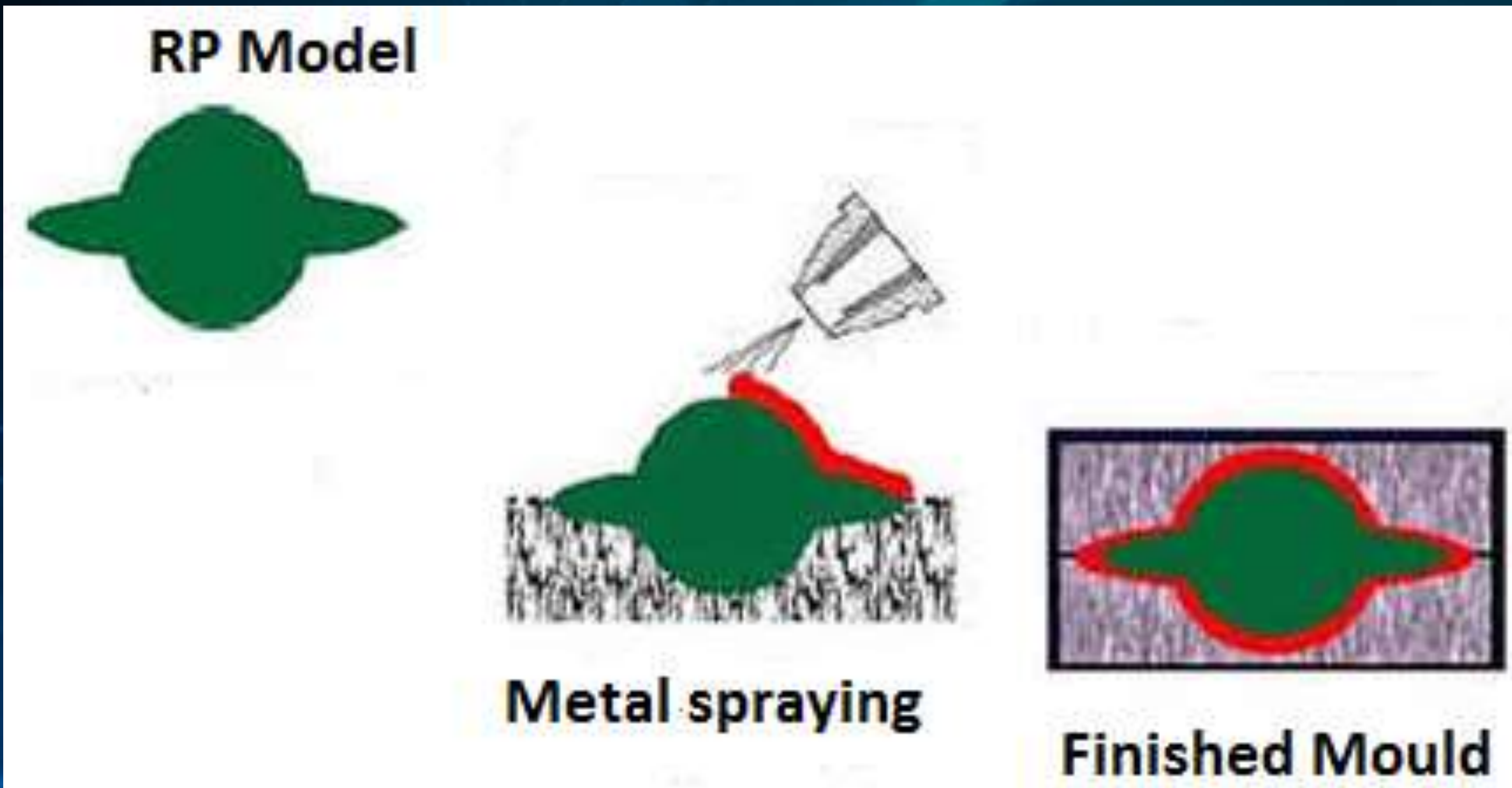
Composite Tool Life Expectancies

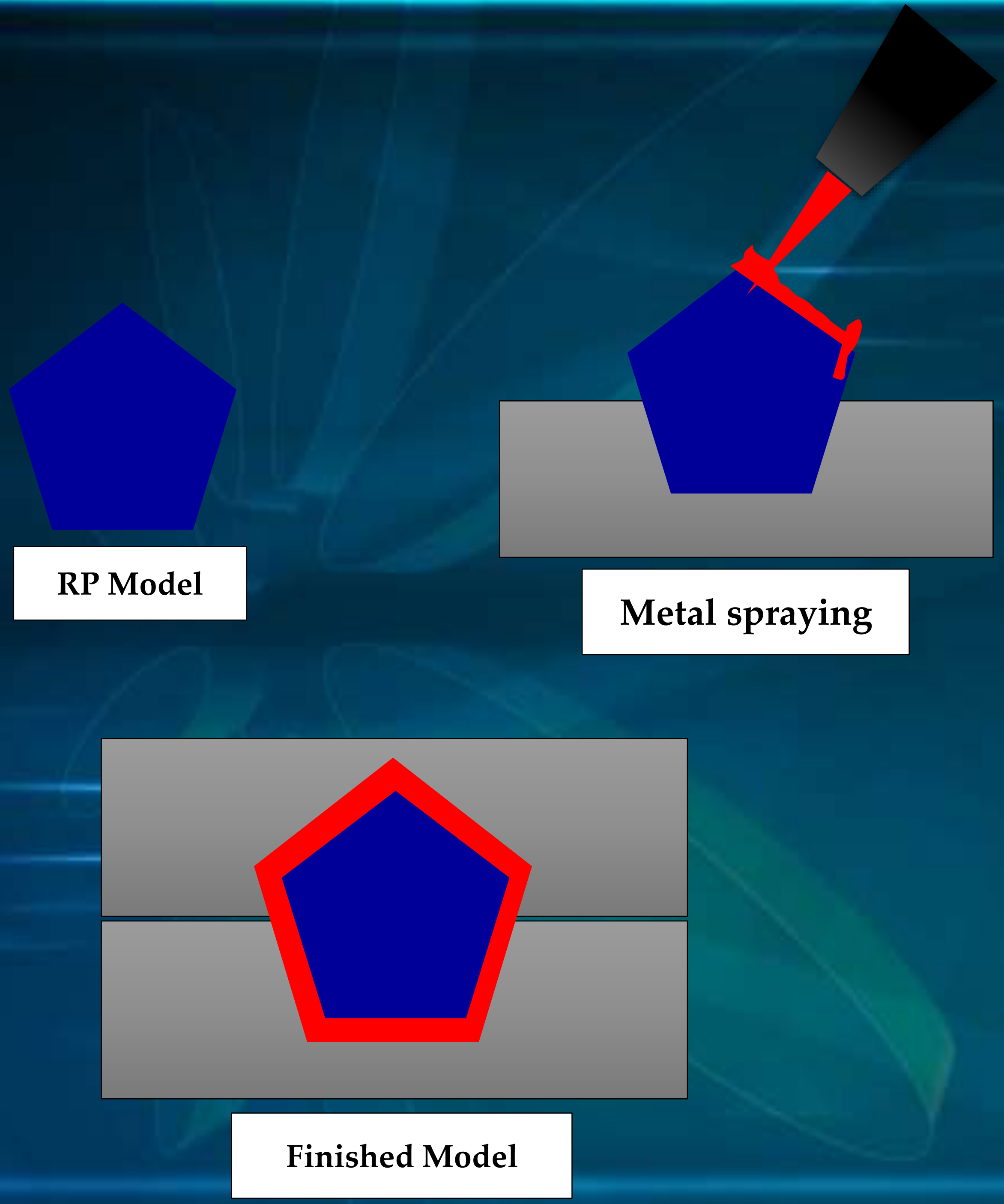
Thermoplastic	Tool Life (# shots)
ABS	50 - 3000
Acetal	100 - 1000
Nylon	250 - 3000
Nylon (Glass filled)	50 - 200
PBT	100 - 500
PC/ABS blends	100 - 1000
Polycarbonate	100 - 1000
Polyethylene	500 - 5000
Polypropylene	500 - 5000
Polystyrene	500 - 5000
Investment Casting Wax	1000 -10000

Spray metal tooling

- It is very similar to aluminum filled epoxy
- In this process, against the RP pattern low temperature metal alloys is sprayed
- A thin metal coating is then arc-sprayed on the resultant mould surface
- It gives higher strength and maximum tool life
- This process is suitable for larger parts

Process:




RP Model
Metal spraying
Finished Model

Spray metal tooling

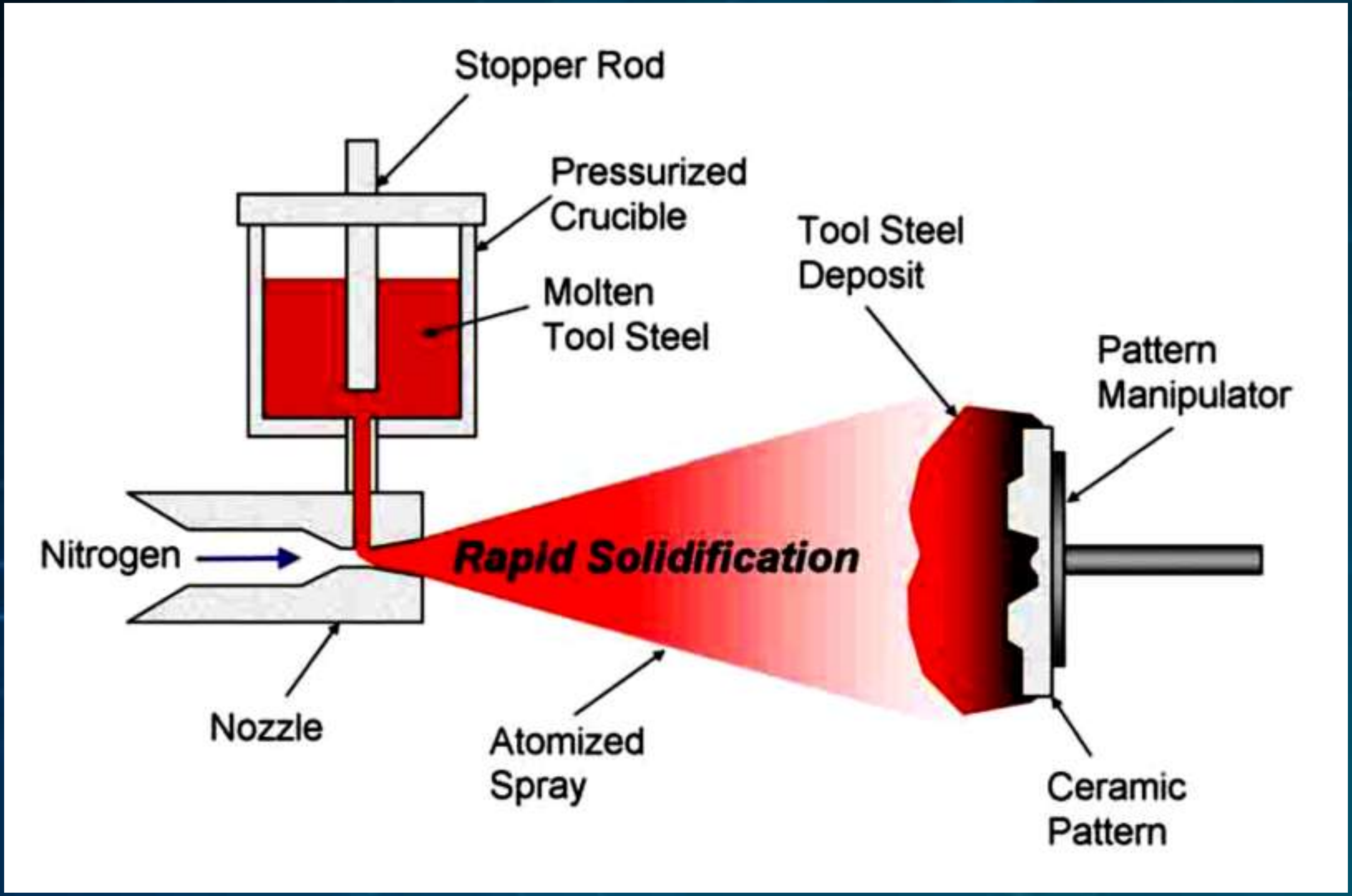
Advantages:

- Very good for large parts
- No or less shrinkage
- Highly accurate

RSP Tooling

- RSP stands for Rapid Solidification Process
- We create a plastic model using SLA
- And then we make moulds with either by epoxy tooling or spray metal onto it
- But most of the cases, ceramics are used
- What's significant in that is that we atomize the metal down to as small as 5 microns.
- When the metal hits the ceramic, because of the small size of the droplets, they freeze very quickly, thus the rapid solidification.
- This process results in extremely fine grain structure and the alloys generally stay in solution and there is very little internal stress

RSP working principle



Cast Kirksite

- **Kirksite is a zinc-aluminum alloy with excellent wear resistance.** (94 percent Zn, 6 percent Al) with a melting point of 385ºC)
- **The process for making cast kirksite tooling begins much like the process for epoxy-based composite tooling, except that two additional reversals are required to permit the creation of tooling in a more durable material**

Cast Kirksite tooling

Cast Kirksite Process:

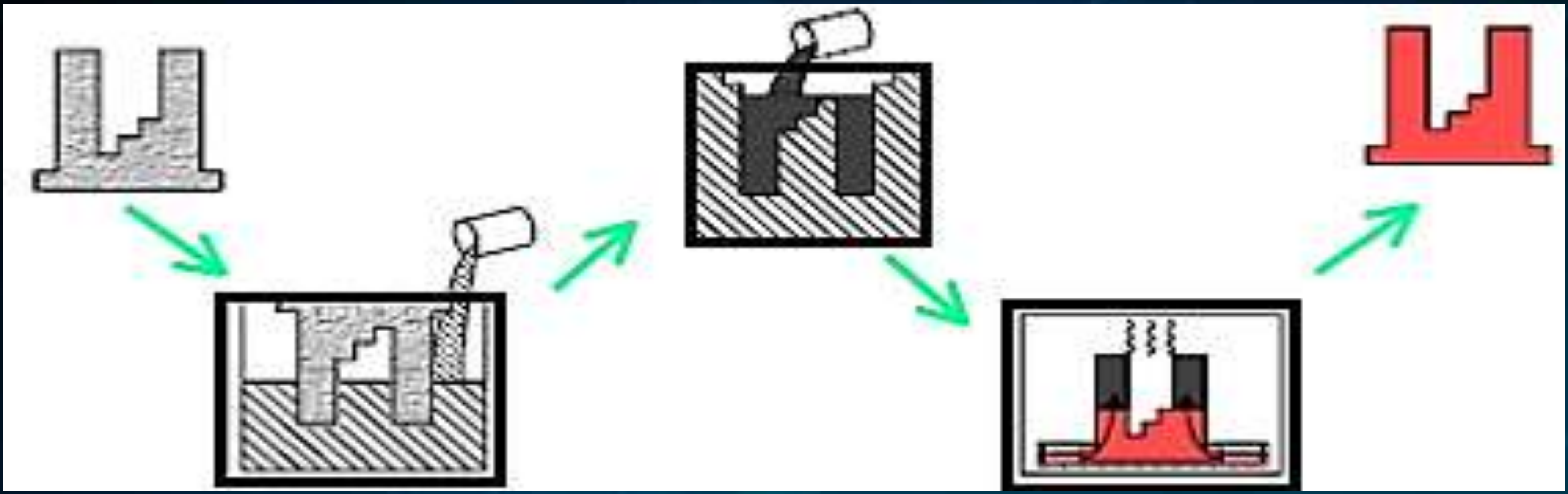
- First, a shrink-compensated master pattern of the part is produced, typically using an RP process.
- A rubber or urethane material is then cast against the part master to create patterns for the core and cavity set, which will be cast in kirksite.
- Plaster is then cast against the core and cavity patterns to create moulds into which the kirksite is cast.
- Once the kirksite is cast into the plaster moulds, the plaster is broken away, and the kirksite core and cavity are fit into a mould base

3D Keltool

- 3D Keltool is a powder metal process used to make injection-mould inserts and other durable tooling from master patterns
- It is very similar spray metal tooling
- Keltool was originally developed by 3M in 1976 and was sold and further developed by Keltool Inc. In 1996, 3D Systems purchased the technology from Keltool Inc. and renamed it 3D Keltool

3D Keltool

- The word "Keltool" refers to the proprietary powder metal sintering process, which involves infiltrating a fused metal part with copper alloy.
- This alloy fills in the voids in the otherwise porous material, producing a surface with the finish and hardness necessary for an injection mould



Process chain of 3D Keltool:

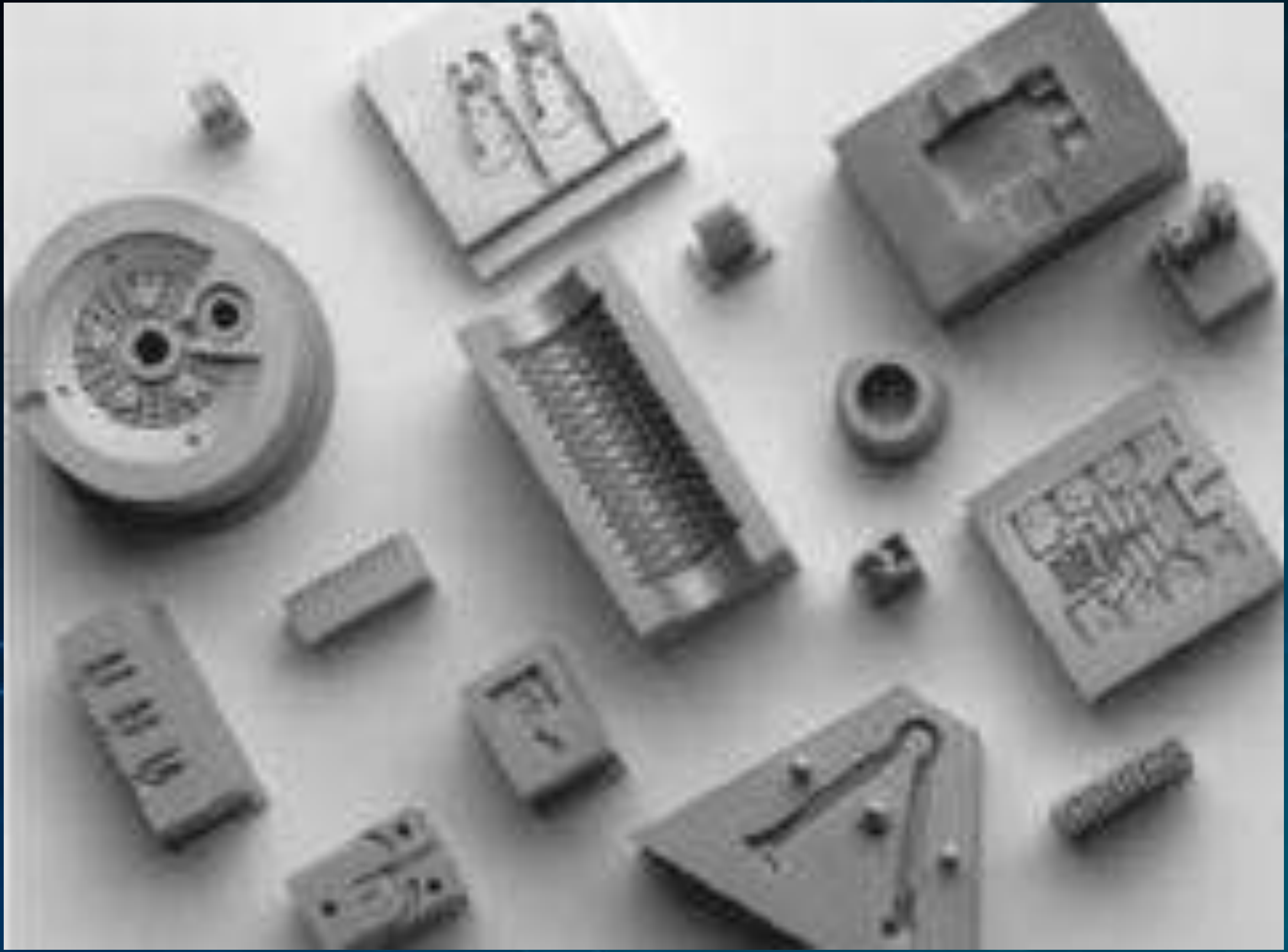
I. Master pattern

II. Silicone casting

III. Casting with a tool steel/Tungsten carbide/epoxy mixture

IV. Burn-out of binder, sintering and infiltration with copper in an oven

V. Tool insert ready for production



- This process requires a master pattern, typically an SLA model, that can be used to develop a silicone mould that will then be used to produce the Keltool mould.
- The Keltool mould is then processed with a copper infiltration and sintered to increase its strength and cure the mould.
- The finished Keltool part has the hardness of a A6 Tool Steel and can be machined like a traditional hard tool.

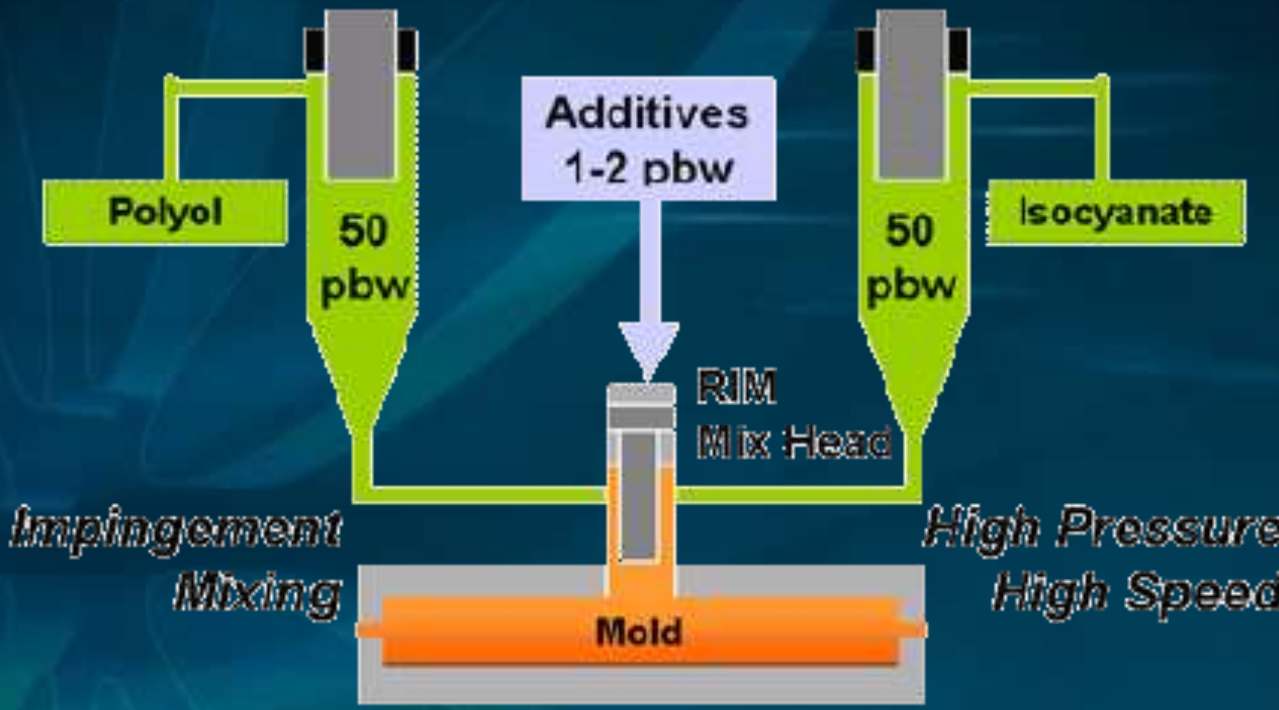
RIM (Reaction Injection Moulding)

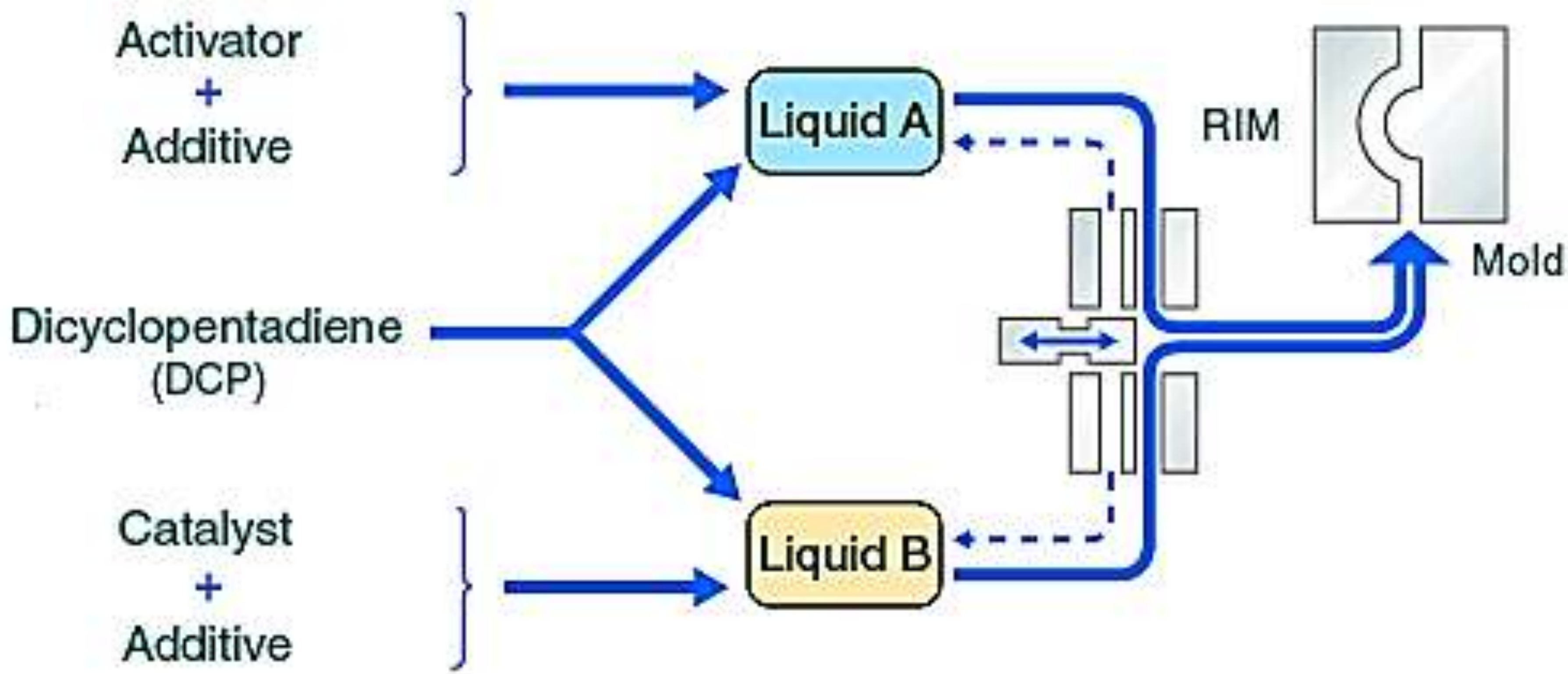
- Very similar to injection moulding
- But here we use thermosetting polymers
- RIM requires a curing reaction to occur within the mould

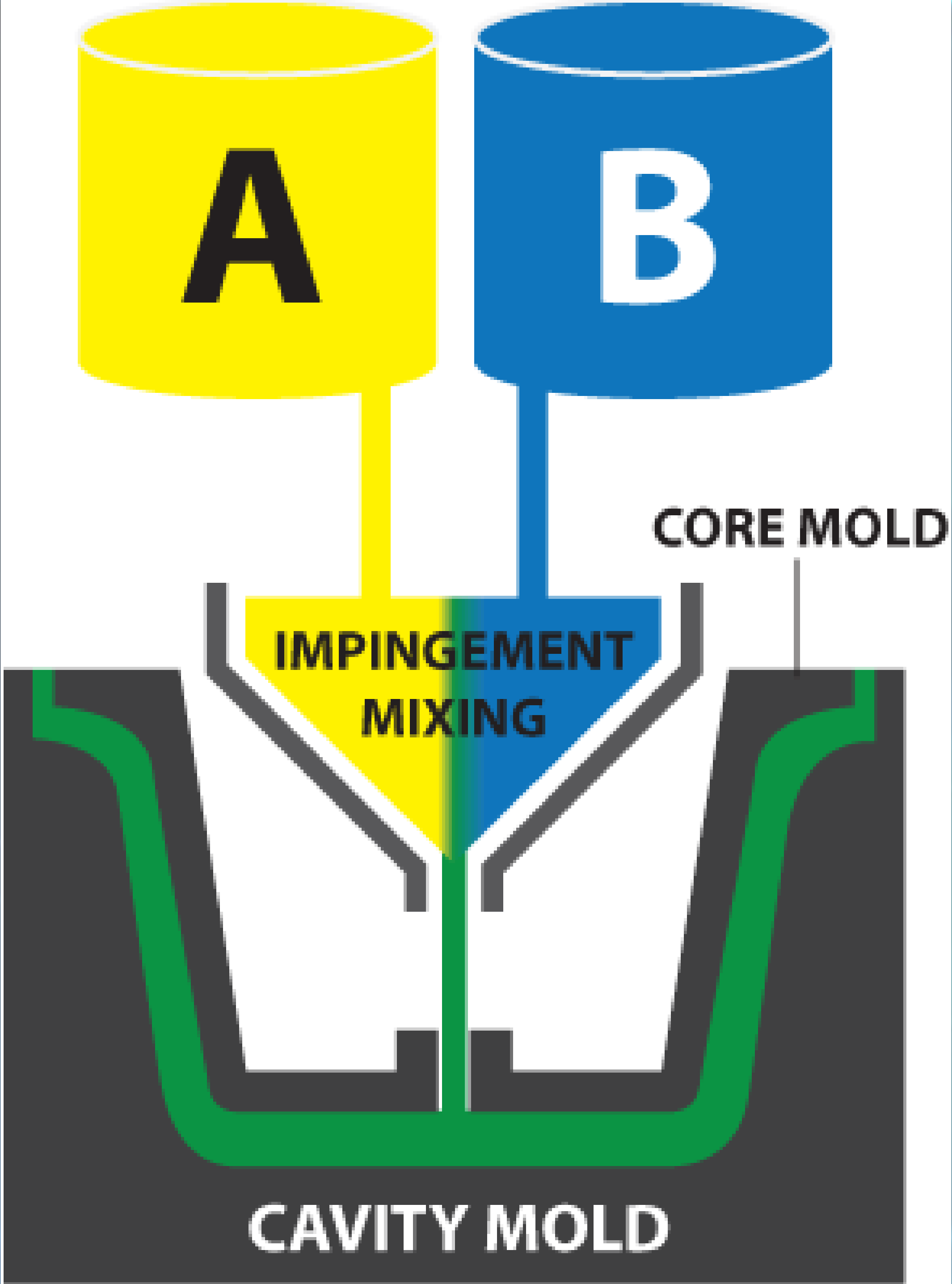
RIM process

- Two highly reactive liquid monomers are carefully metered, brought together in a mixhead, and immediately injected into a heated mold under low pressure

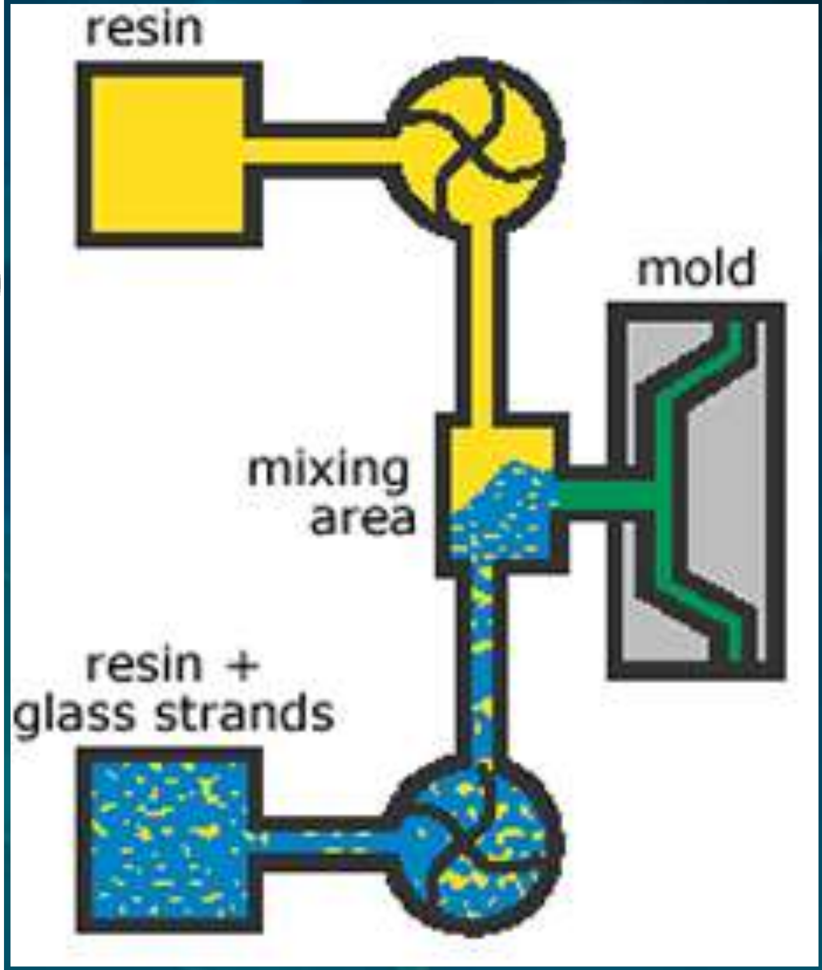
- The mixture is allowed to sit in the mould long enough for it to expand and cure

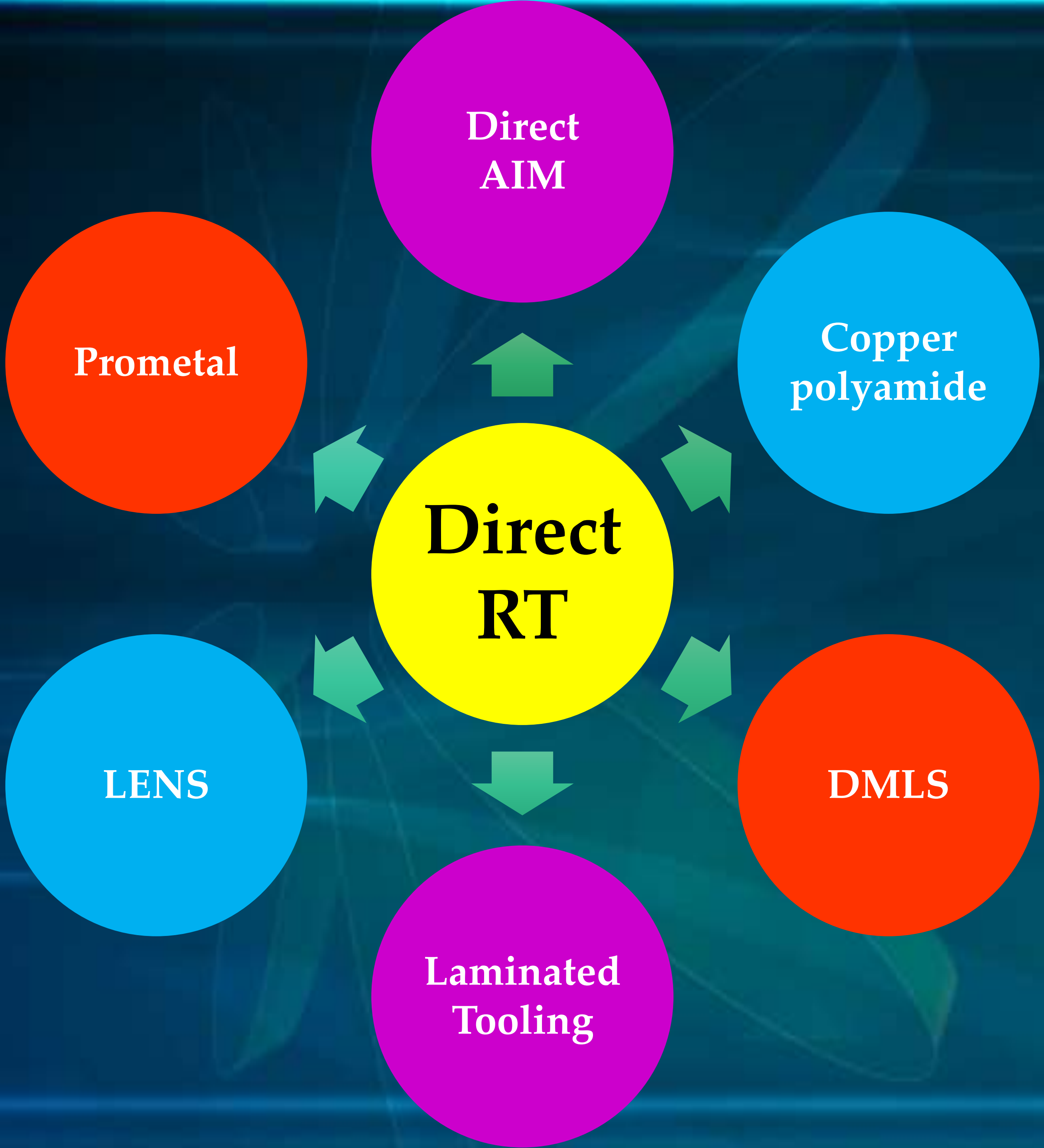



Activator
+
Additive
Liquid A
RIM
Mold
Dicyclopentadiene
(DCP)
Catalyst
+
Additive
Liquid B



Common items made via RIM include automotive bumpers, air spoilers, and fenders (used for mud prevention)




Direct RT
Direct AIM
Copper polyamide
DMLS
Laminated Tooling
LENS
Prometal

Direct AIM (ACES Injection Moulding)

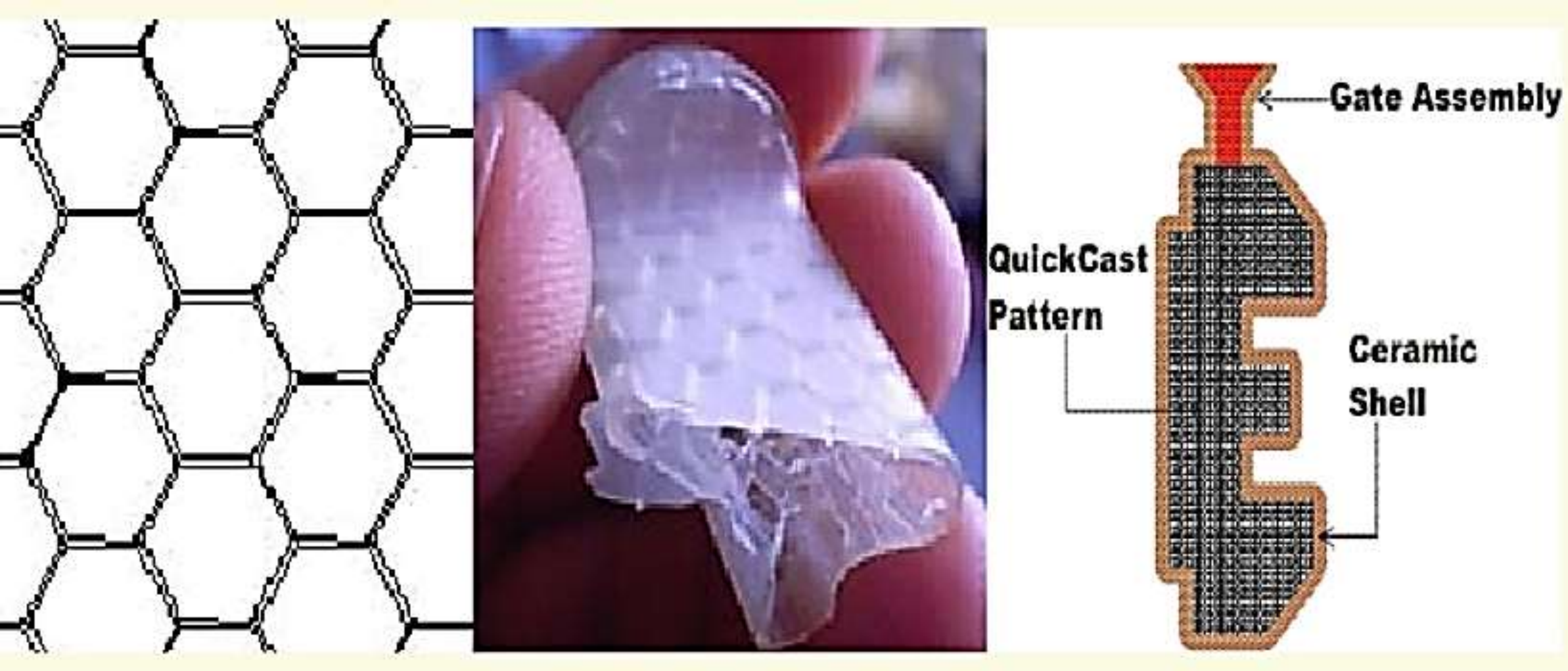
- In the AIM process, the mould is "grown" using the SLA process.
- The mould is similar to a regular part SLA, but is the negative image and cut into two halves.
- The cavity can be filled with a variety of materials, including:
- Thermoplastics
- Aluminum-filled epoxy
- Ceramics
- Low-melt temperature metals

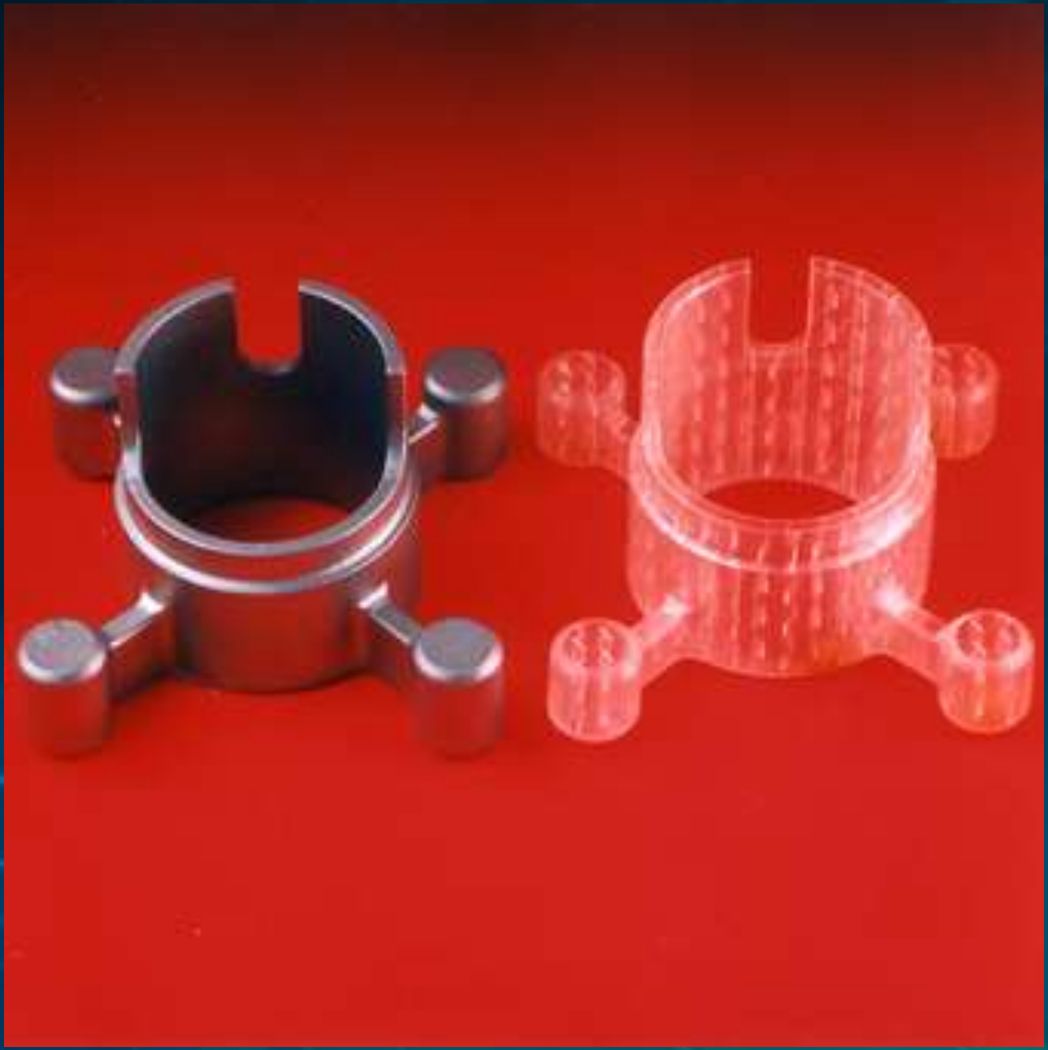
Direct AIM tooling

Quickcast Process

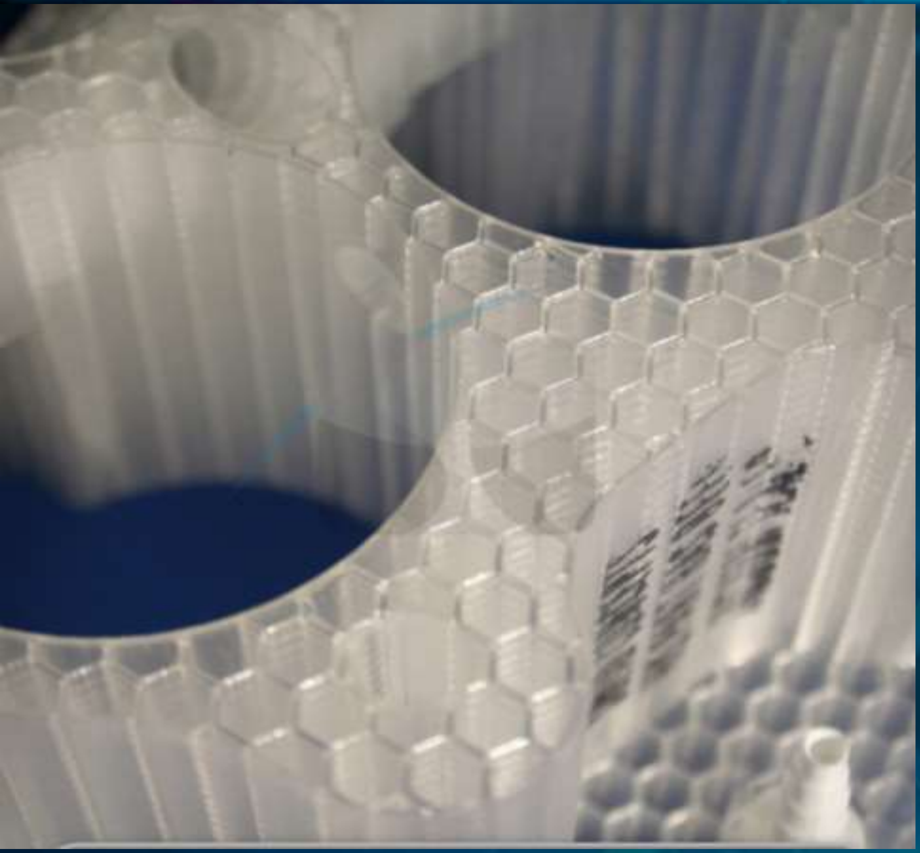
- QuickCast is a process that allows for the creation of direct shell investment castings using "QuickCast" Stereolithography (SLA) patterns.
- The QuickCast method allows you to rapidly build highly accurate resin patterns in Stereolithography, bypassing the expensive and time-consuming step of tooling.
- QuickCast facilitates rapid production of small quantities of metal parts in much less time than traditional methods.
- Instead of the SLA part being completely solid, QuickCast eliminates 95% of the internal mass of the part.

QuickCast Process:





QuickCast Stereolithography resin model and steel casting



Investment casting patterns made by QuickCast

Copper Polyamide

- This process uses the essence of SLS
- Here we use Copper Polyamide powder matrix
- Copper Polyamide is a new metal plastic composite designed for short tooling applications
- Tooling inserts are produced directly in the **SLS machine** with a layer thickness of 75 µm.

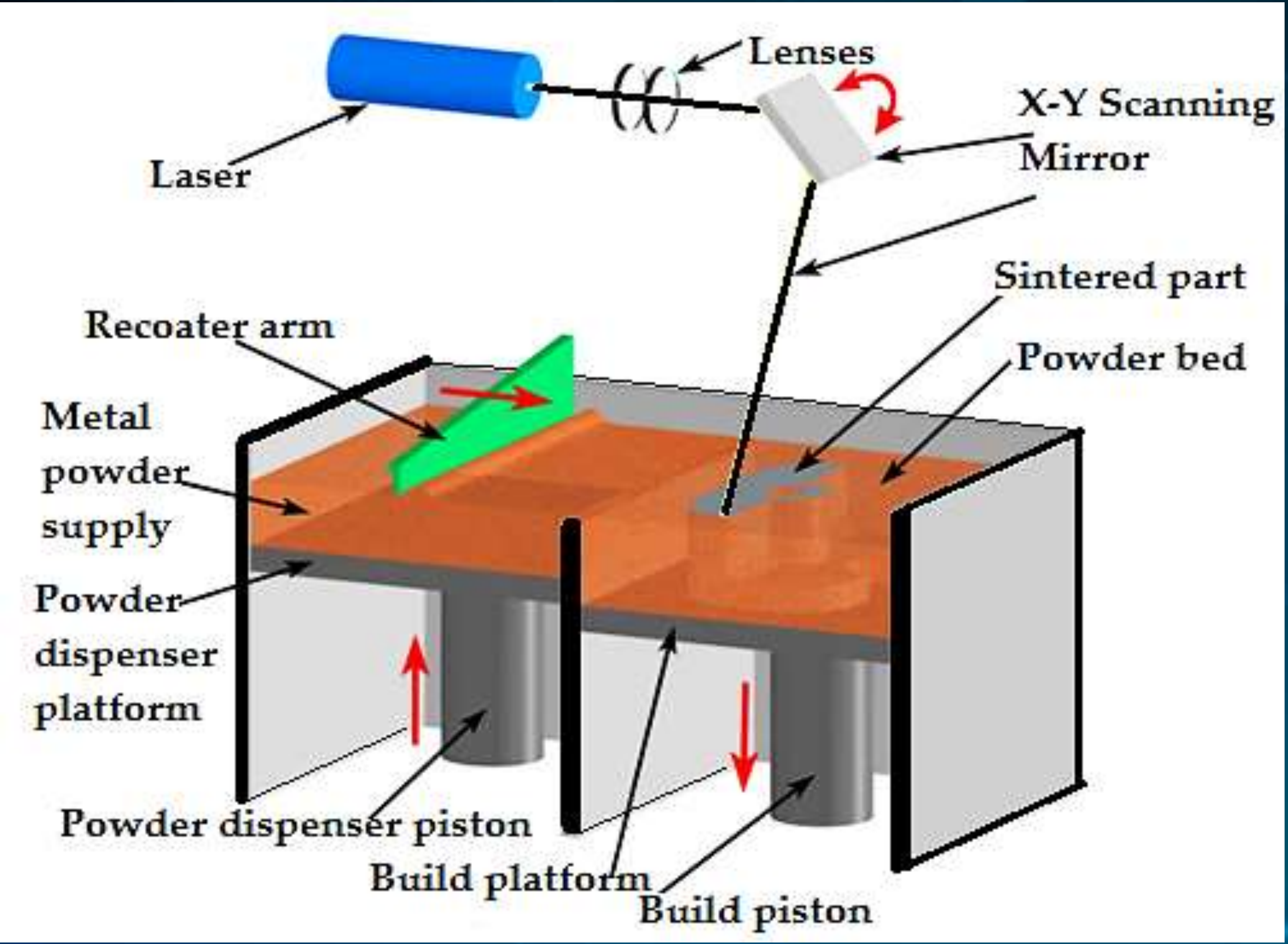
- Subsequent **finishing is necessary** before their integration in the tool base.
- During the CAD stage, Copper polyamide inserts a shelled and cooling lines, ejector pin guides, gates and runners are included in the design and built directly during the SLS process.

- Then the insert surface are **sealed with epoxy** and **finished with sand paper** and finally the shell inserts are **packed up with a metal alloy**.

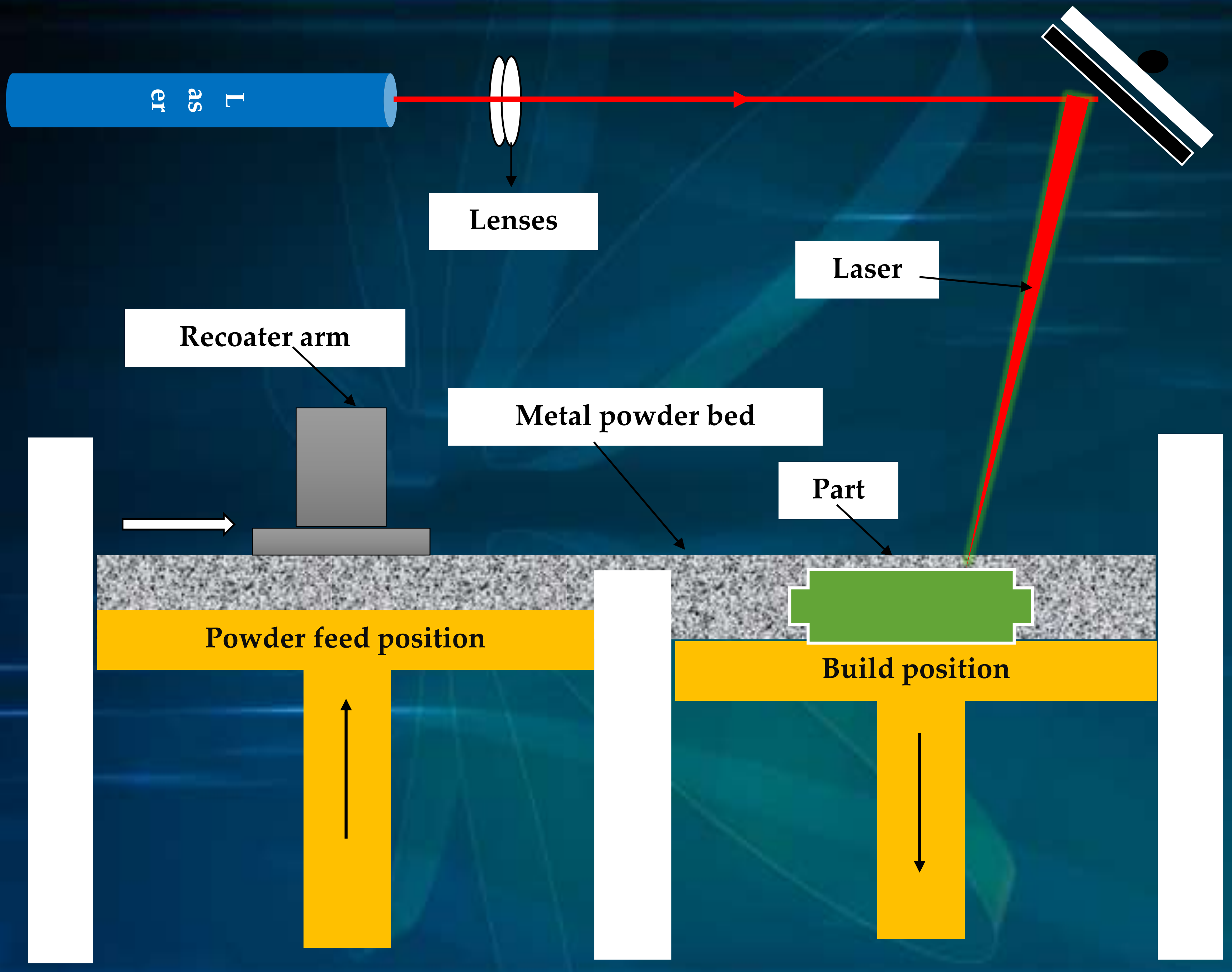
Advantages

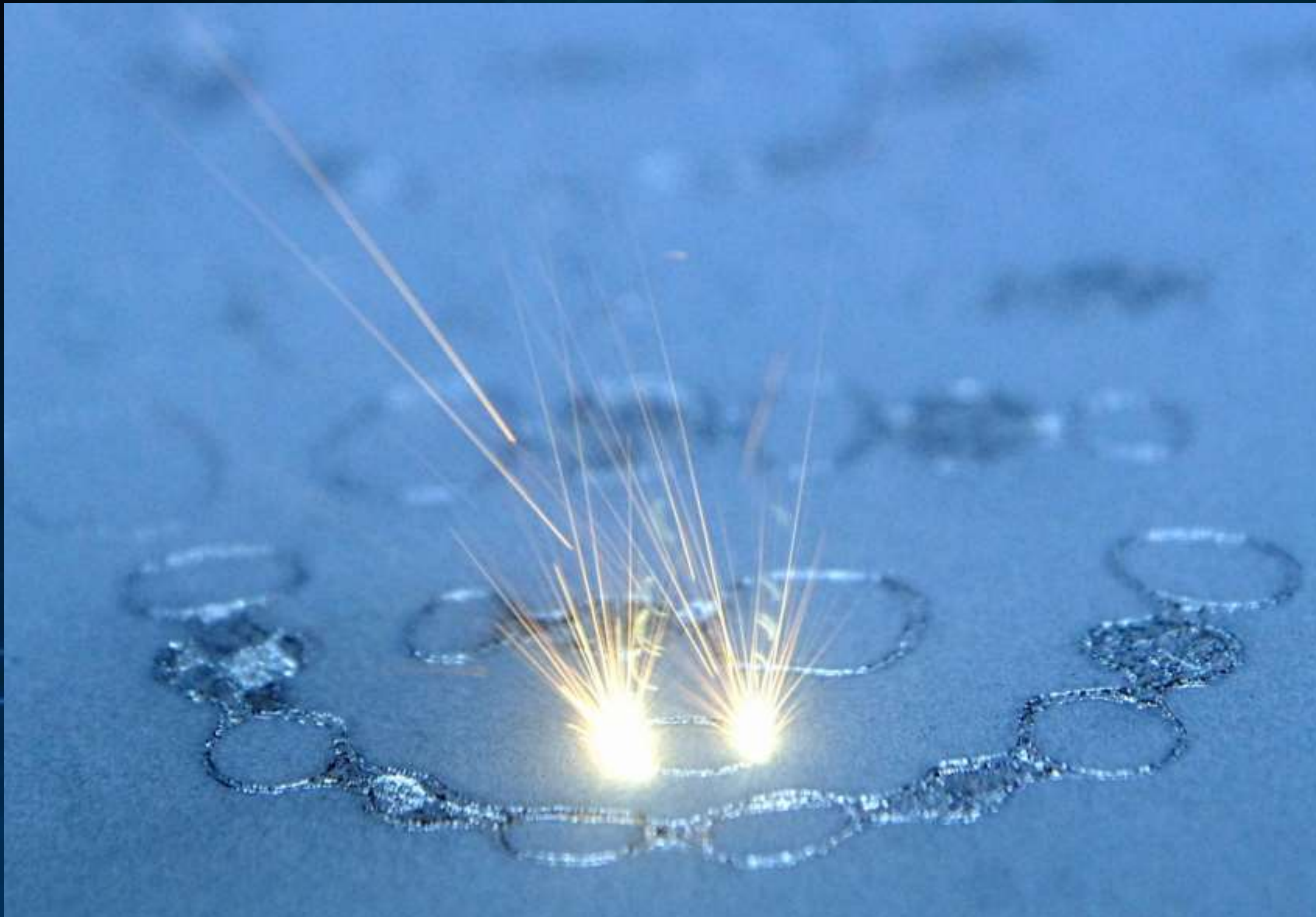
- Inserts produced from copper polyamide are **easy to machine and finish**.
- **Heat resistant** and **thermal conductivity** are better in most plastic tooling materials.
- The **cycle times of moulds** employing copper polyamide inserts are similar to those of metal tooling.

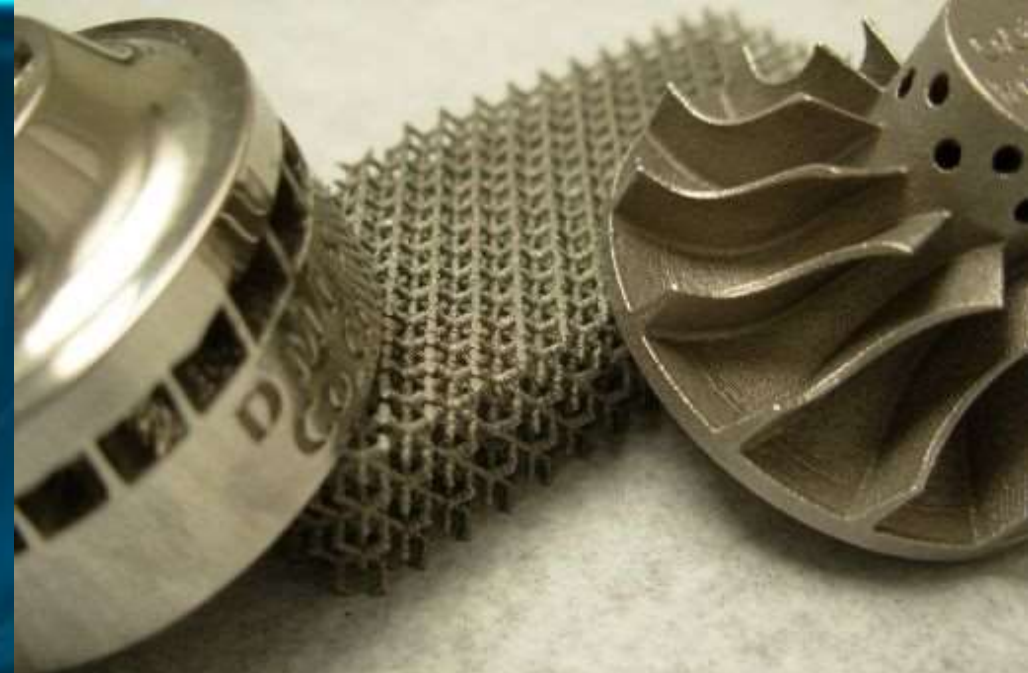
DMLS



Lenses
X-Y Scanning
Mirror
Laser
Sintered part
Recoater arm
Powder bed
Metal
powder
supply
Powder
dispenser
platform
Powder dispenser piston
Build platform
Build piston


Laser
Lenses
Laser
Recoater arm
Metal powder bed
Part
Powder feed position
Build position






API

Materials

- Currently available alloys used in the process include *17-4* and *15-5 stainless steel, maraging steel, cobalt chromium, inconel 625* and *718*, and *titanium Ti6Al4V*.
- Theoretically, almost any alloy metal can be used in this process once fully developed and validated.

Applications

- DMLS is a very cost and time effective technology.
- DMLS is used to manufacture direct parts for a variety of industries including aerospace, dental, medical and other industries that have small to medium size, highly complex parts and the tooling industry to make direct tooling inserts.