# *5 Things Everyone Should Know About Micro-Molding*

Remember this guy?

Circa 1983 Motorola introduced their grey, “Brick,” cellular telephone taking mobile communications out of the bag and into our hands. It was big, clunky and it ONLY made phone calls. It was expensive to buy and even more expensive to operate. Initially it was a very exclusive crowd that carried technology like this.

Then as time went on the technology developed. The phones got smaller and cheaper to use. The functionality improved and the batteries lasted longer. More and more people adopted the idea that having mobile technology was beneficial to their lives, and new demand was created.

Fast forward to today….

No one needs to explain what’s happen to the cell phone industry since 1983. The functionality has far surpassed its predecessors and today’s phones perform more like devices that were once limited to science fiction. Today these “smartphones” are very assessable and are no longer an exclusive technology. Just ask your 8 year old how many of his friends have their own phone.

Just as with cell phones, product development is an evolution of pushing limits. With each new design we strive to make our products smaller, faster, cheaper, better. The cell phone industry seems to have hit a point where the phones are not getting any smaller; in fact the current trend seems to be going the other way.  Now the issue is back on the inside. How can I get more into the same footprint? That’s were technologies like micro-molding come into play.

Micro-molding technically is not new; it’s been around at least as long as the “Brick” cell phone. However not every industry was ready for it 25 years ago when micro electronics was a completely different industry. It’s really only the last 10 years or so where the use of micro plastics has exploded and to many has become an enabling technology for their next generation products.

Ironically micro technology has not only helped shrink things but it has also allowed us to grow things as well. Who remembers when having a 32” TV was big? Today you can have a 54” wide screen or bigger on your wall with no trouble at all.

Not that long ago this is what it took…

Today micro technology has shrunk the components of what it takes to build things bigger. The same things that give small cell phones more power give big things an opportunity to be bigger…, cheaper…, better.

So what does this all mean to you?

In many ways we're all trying to accomplish the same things. Make that next surgical device less invasive, make that next product more cost effective, or make that next component do more in less space.

To help make that next dream a reality the rest of the conversation will focus on the five key components of micro molding we believe everyone should know. Like anything new, knowing what it can do for you, how you can take full advantage of the process, or where it can take your deign is essential in maximizing the value.

At the end of the day you have to design a functional product and our goal with this conversation is to help you understand how best to approach micro injection molding so that it's the DESIGN that wins the creative battle.

## 1. The Design: Understanding the Approach

The first thing we think everyone should know about micro molding is understanding the approach. If you are to maximize your design, knowing what you can and can't get away with is the first step. As with many equations the concept of, "Start with the end in mind" is familiar. This can be especially true with micro molding since even the slightest design change along the way can derail a project.

For example, when you're talking about a project with a .005" wall thickness a 5% dimension change can be the dividing line on whether the part will fill. Resin changes can also affect a part with this kind of detail. Stack dimensions and stack tolerances are nothing new to part design. However as the parts get smaller the amount of change becomes more of a limiting factor.

Part design exclusive of its final functionality can have adverse effect if the part design and its mating parts have little room for changes. For example, if you're designing a part that fits in a catheter tube the ID of the tube cannot change. Therefore, the limit of what the OD of your design can be is critical.

The second thing to note here is the process by which your parts are made, especially with prototypes. Its mission critical to know you have a manufacturable path. The advent of the PC in the design and manufacturing world has done wonders for our speed, creativity and complexities. It has freed us so we have more time to design, create, try and compose.

Of course the unintended consequence is that the software allows us to "draw" things we cannot actually make. Sometimes it can be really obvious the design won't work but other times more subtle, like part size. The PC allows us to see and zoom in on parts that in reality are only a few hundredths of an inch or even microns in size. Sometimes this allows us to design theoretically correct parts but in reality they are not moldable. Designing at this scale requires careful attention to what might otherwise not be a big issue for larger part designs.

So with all this to keep in mind… What are the guidelines of designing for micro molding?

That unfortunately is an easier question to ask than define. There are way too many variables involved to make any hard and fast rules. We have found time and time again that different geometries and/or material selections can have dramatically different outcomes. That being said there are a few things we can point out as general guidelines for you to consider.

- Gates as small as 0.1mm
- Ejector pins as small as .25mm
- Aspect ratios around 6:1 (material dependent)
- Be mindful of thick-to-thin wall transitions
- Watch wall thickness uniformity
- Ribs as a % of wall thickness
- Know how shrink rates will affect the part
- Understand parting line mismatch
- Flash & Witness Marks
- Draft is still welcomed

Primarily it's important to remember that it is still injection molding and the same physical rules of gating, parting line and ejection still apply. But as you will see throughout this conversation these guidelines are very general and it's usually a good idea to speak with your micro molder about your ideal concepts before "dumbing" down your part design. DON'T LET these guidelines stifle your creativity! That's how we push the limits.

## 2. Material Selection: Beyond the Data Sheet

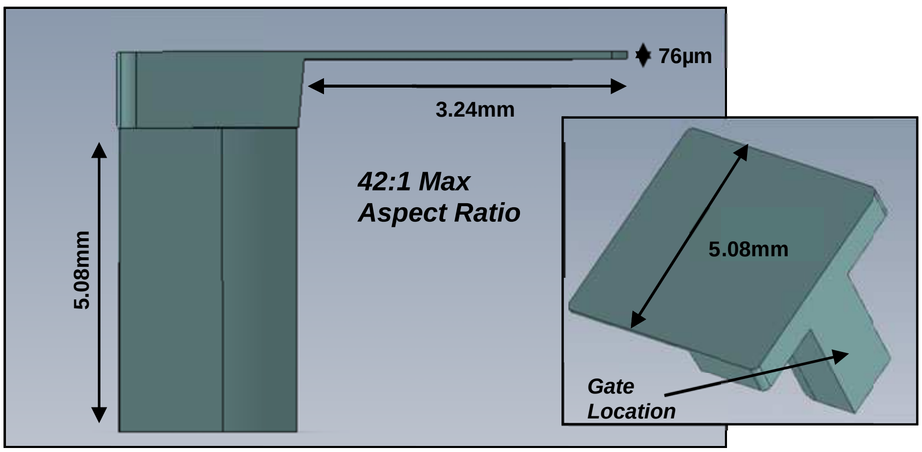
The second thing we think everyone should know in order to push the limits with micro molding is material selection.

According to IDES.com Prospector there are over 85,000 data sheets from over 860 different resin suppliers worldwide (http://www.ides.com/about/story.asp). That's a lot of plastic to choose from. Of course from there you can custom compound many of these base resins and the list just gets longer.

Material selection alone can be difficult enough when it comes to choosing what works best for your product's needs. The challenge comes when you've finally decided which material will work and you now have to decide if it will be moldable into the shape you need. At the micro level, and the more extreme you are looking to push the limits, the more difficult this task can be.

Where do you begin?

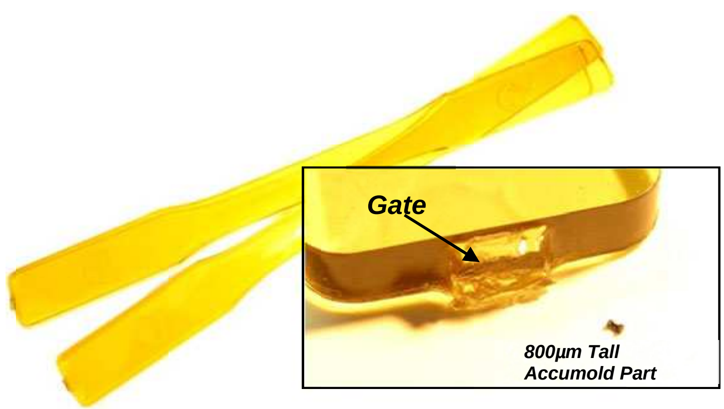
Most often we hit our database of resins trying to match up what the part calls for and the choices available. We may contact our favorite resin supplier to get advice on what materials will be best suited for your needs. That may be more difficult than it seems however.




To demonstrate what relation material selection has to pushing the limits in micro molding we decided to build a sample part and put it to the test.

We built a mold to produce this part with a very thin section to see how material selection alone can affect moldability. The thin section is 76µm or .003" thick. The mold was built with an optimal thick to thin transition and good gate and ejection locations to maximize the opportunity each material we chose would have to fill to the end, a full 42:1 aspect.

Next we set off as one might normally; with data sheets.




The problem is that most data sheet information is based on much larger parts. In the image to the right we see a common "dog bone" sample from a resin vendor. The data sheet's recommended gate size, flow properties, etc. are all based on this much larger part. You can clearly see the gate as it compares to an actual molded part only 800 microns tall.

This can be a very deceiving starting point. The frustrating thing is you could ultimately come to this barrier and decide your part is not moldable and either give up or alter the project in a non-ideal manner. While the design process can end at this step on some occasions it doesn't always have to. Remember when pushing the limits you're bound to run into a few barriers.

Next we decided to ask the resin experts themselves for their advice. Certainly they know their materials and what may or may not work. Here are a few of the responses we got back when we asked them what material they would recommend to mold this part.

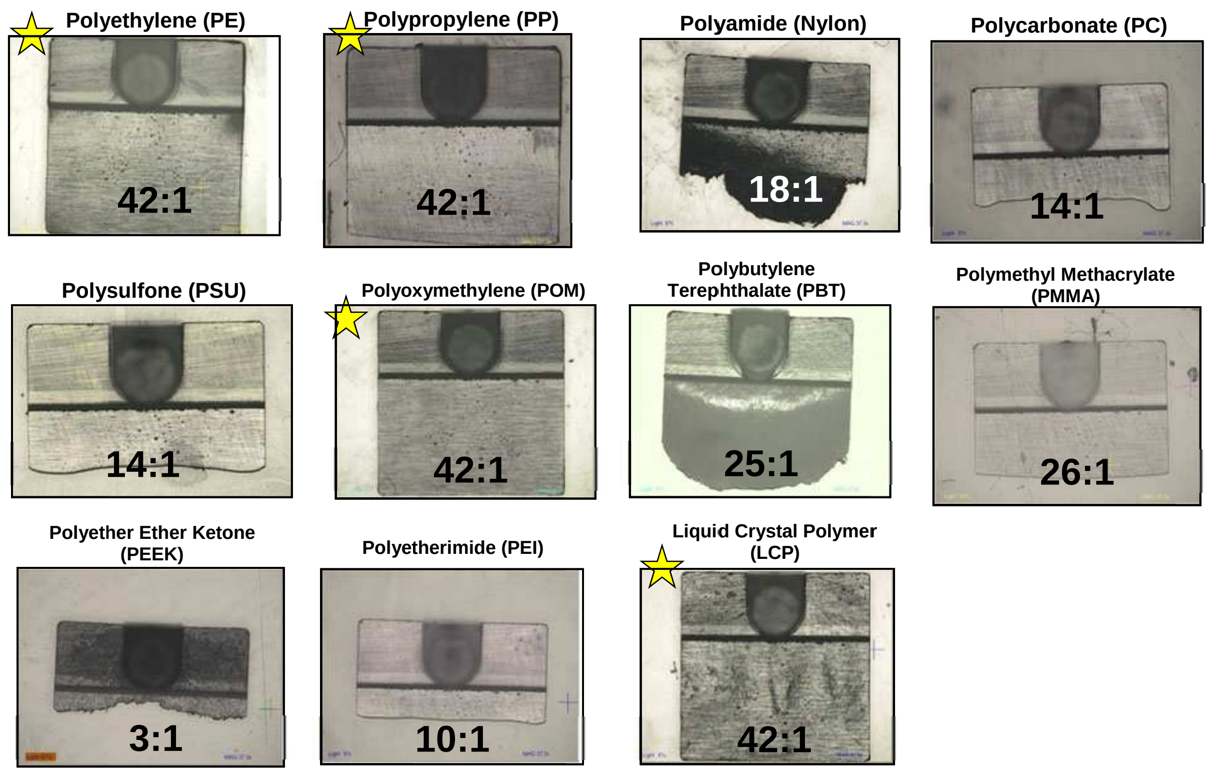
- *"The wall thickness would require an increase of 5x to 10x the current .003" in order to fill."*
- *"Molding the part thicker and grind it down to the desired thickness."*
- *"In looking at the part, the .003" section will not fill any of the listed materials. In fact, I believe you will be hard pressed to find a thermoplastic material that would fill that .0127" long, .003" wall."*
- *"I do believe you would need to be in the .015" wall thickness zone."*
- *"We would suggest increasing the .003" wall thickness to at least .015" or, better yet, .030" in order to improve moldability.*
- *"In my opinion filling this geometry would not be possible in a production environment. I would consider trying to mold a PP at approximately .016" - .018" and an Acetal 9 melt at .025".*

Again this can be a discouraging step if you're convinced now your part is not moldable as is.

We push on…

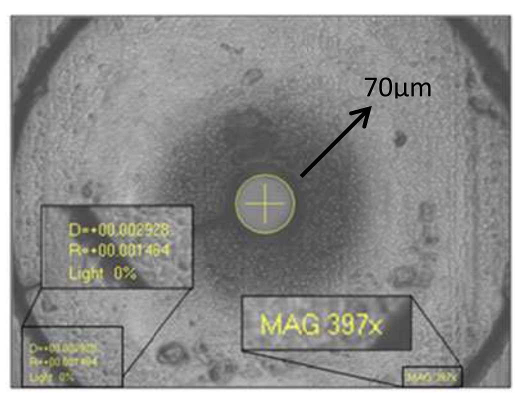
We chose 11 different materials that we see every day and put them to the test to see how each material would fill the thin sections. Many of these are highly engineered resins, some with glass or other fillers as well.

1. Polyethylene (PE)
2. Polypropylene (PP)
3. Polyamide w/ 30% Glass Fill (Nylon)
4. Polycarbonate (PC)
5. Polysulfone (PSU)
6. Polyoxymethylene (POM)
7. Polybutylene Terephthalate (PBT)
8. Polymethyl Methacrylate (PMMA)
9. Polyether Ether Ketone (PEEK)
10. Polyetherimide (PEI, Ultem)
11. Liquid Crystal Polymer (LCP)




As you can see there was a wide variety of results. Four of the chosen resins actually made it the entire 42:1 distance! Some of the rest went well past the guideline of 6:1 and some, like PEEK and Ultem, didn't go terribly far at all.

Now here is where it can get difficult. This test wasn't to see how far one could push PEEK at a .003" thickness. It was simply to compare how material selection can greatly determine the moldable outcome all by itself. The test was also not a determination that in all situations the materials will always perform this way. Your results are very much tied to your design. But you can clearly see where data sheets, resin suppliers and your part design can be at odds.




This is why we recommend you work with your micro molder at the early concept stages of design. Don't let material selection keep you from your ideal part design. In some cases it just might not be a problem after all.

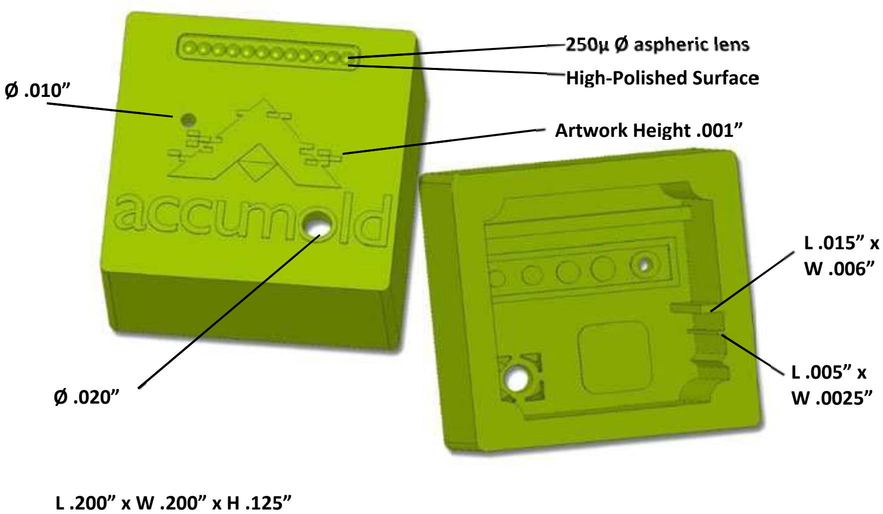
For example the picture at the right is an Ultem (PEI) part with a 70µm through hole. As we saw Ultem can be tough when it comes to filling small areas. Part design can sometimes allow even stubborn materials a chance at creating small details.

## 3. Prototyping: The Challenges in Development

The third thing we think everyone should know about micro molding is prototyping.

Here again is another potential barrier you may face when developing parts for micro molding. Prototyping as you know is a regular part of any design process. There are also many different reasons one might need to prototype a part. Certainly mechanical functionality is a key driver, but cosmetics, material compatibility or longevity also may play a huge factor in how you approach the prototyping phase.

If you've ever sent out a micro part for quote to a prototyping service bureau then, like some of the material selection responses we saw, you've probably run into a few challenges yourself. Prototyping for micro parts or features can be a major hurdle even to the point of changing your part design if you can't achieve what you need to move your project forward. However unlike material selection, prototyping isn't just a "try it" kind of process in a lot of ways and there are definitely limiting factors in today's commercially available prototyping processes.




What can you do?

In order to answer that question we built another test part.

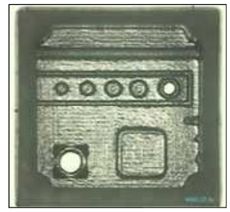
This time we built a part with the size and type of features we see on a regular basis. The goal was to send this part out to be prototyped by as many of the common, readily available prototyping process we could find.

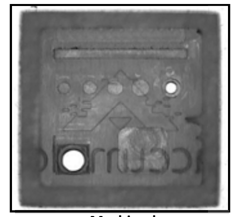
Now this study was not to judge these different processes themselves. They all have places where they are a very effective. In some cases any of these processes could produce what you may need in a prototype. However we wanted to look at the more extreme side of the equation. Since we're trying to push the limits with molding it's going to push the limits of prototyping for sure!

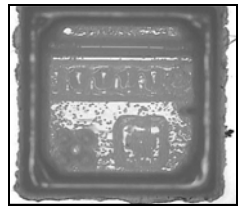
We tried to approach this as any of you would. We designed a part and searched to have it prototyped. We sent the part out for quote to server bureaus that offered these 11 different processes.

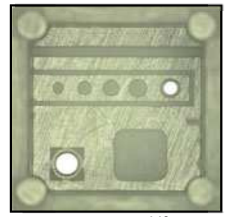
**Selected Services:**

- Stereolithography (SLA)
- 3D Printing
- PolyJet
- Fusion Deposition Modeling (FDM)
- Selective Laser Sintering (SLS)
- Laminated Object Manufacturing (LOM)
- Cast Urethanes
- Machining/Rapid Tooling
- Rapid Injection Molding (RIM)
- Standard Hard Tooling


SLA


Machined


PolyJet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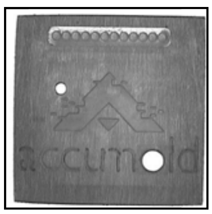
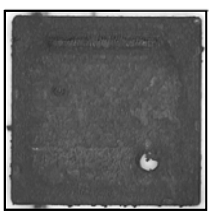
Of the 11 different processes we had 5 respond and the rest "no quoted" the opportunity. SLA, PolyJet, Machined and Standard Hard Tooling all netted fairly good results. The 5th one we received was from a 3DS printer. It appeared more like a sugar cube, and only the basic square shape was produced.


SLA


Machined


PolyJet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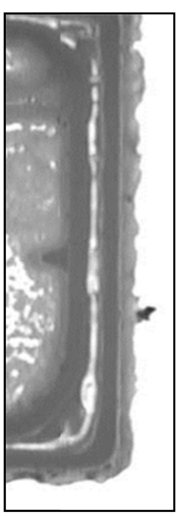
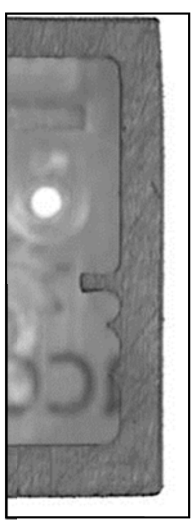
Originally when we embarked on this study we thought we might have to get the scope out and measure the fine details in order to determine which parts met print. However, as you can see, the feature performance is fairly obvious.

Before you call one process successful or not you'll have to judge it against your needs. For example the image to the left is the top side of the part. The row at the top is a series of 250µm diameter lenses. The "whiter" the image the more "polished" the finish is on the part. You can see here the molded part was the only one to replicate the highly polished surface (which it should). The point being, if that's what you need for your prototype to function your prototype options may be very limited. This can also be the case for other needs like feature definition or tolerance requirements.

SLA


PolyJet


Machined


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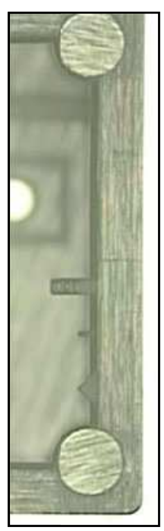


In this view you can really see the different outcomes. The thin tabs final shapes are quite different. Again, your part will dictate what's important in a prototype and can determine how you may approach the process.

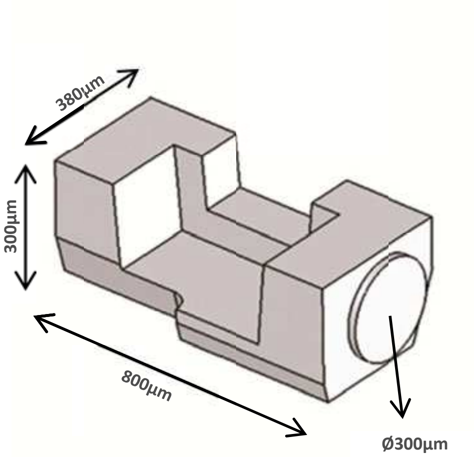
It's also important to note that another barrier with this stage of development is cost and speed. If hard tooling is what you determine is the only process to make your prototype function as needed the cost and speed can be a limiting factor. If you're expecting hard tooling to be finished parts in 1 day for $1000, more like some of the rapid services out there, you may hit a barrier.

While new advancements in rapid prototyping are being achieved all the time (since they are working to push the limits in their own way) there really isn't a rapid micro molding process. There are quick mold programs out there but one is usually talking a week or two, not hours.

The point is to know that prototyping for micro parts can be challenging not only in producing the parts but in the time and cost you may be used to. Factor that in as you design for micro molding.

## 4. Beyond the Part: Metrology, Handling, & Packaging

The fourth thing we think everyone should know about micro molding is post production. What happens once you've actually made the part? Now what?

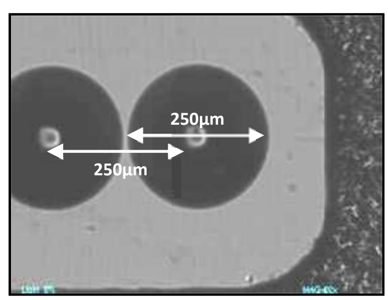



Once you've made the part what are you going to do with it? How are you going to receive it? How are you going to validate it? These are really big questions.

As with prototyping, pushing the limits with one technology also may mean you are pushing the limits and expectations of other processes or equipment as well. What you might not have had issue with before may now become an issue. And since most of you are not in the business of making just one part, final manufacturing can be another barrier to achieving your goals.

For example, the part pictured above has its longest dimension at only 800 microns long.

In this case the challenge was not making the parts, it's what came after. In order for the customer to receive this for their setup it needed to be clocked and oriented in a tape and reel system. That means it needed to picked up and maneuvered in a very delicate and exact way. A part this size does not fall in the everyday, run-of-the-mill pick and place set-ups. Never mind the fact that static would send this part dancing if not controlled.




Another example is with metrology. You're micro molder may have the measurement systems to validate fine features or tolerances but do you? When you're dealing with parts or features that, to the naked eye look "fine" but under the scope reveal more than meets the eye, you'll need to be prepared to develop a validation system that might be different than your standard incoming inspection.

The point is… post mold operations, measuring and/or handling can be a barrier in your development process. Working with your micro molder on the front end of the process about the back end can be equally necessary, especially if your final manufacturing needs will require custom automation or handling.

## 5. Size & Features: I Didn't Know You Could Do That

We usually tell our customers, "Start with your ideal and we'll work from there."

The fifth thing we think everyone should know about micro molding is more of a philosophy than it is a process. Keep driving!

Pushing the limits is by design a creative endeavor driving new innovation every day. When working on the cutting edge there can be many roadblocks to side-track your efforts but hopefully after working through the first four topics you might find hope in meeting your goals.

Below are four case studies of challenging parts that we have produced for our customers. These are a few examples where pushing the limits have made these projects very successful and hopefully at the same time spark your imagination as you work on your own.


Case 1:

This tiny part, made of Ultem (PEI), needed to consolidate several functions into a very small package. It has a 100µm aspheric lens with a 125µm base radius on one side and a small turning mirror on the opposite. It also has a tri-lobed press-fit slot at the bottom to receive a 125µm diameter fiber.

This fiber holder not only requires very tight tolerances on its very small features, it also requires an optical surface finish and clarity for the light path to be successful. The Ultem provides the stability and transmissive properties needed for the project. The challenge came in building the tool and managing the processing to fill out the micro features with this difficult material.

Case 2:

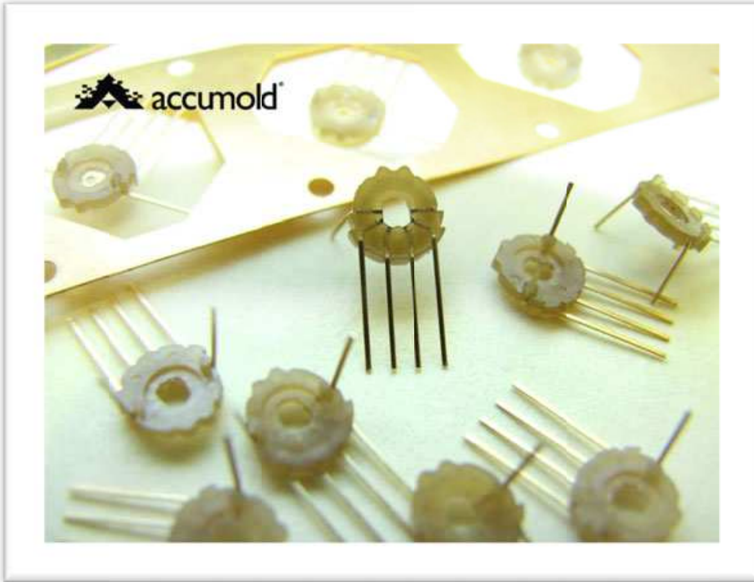
In this case a delicate fabric mesh needed to be overmolded into the 2mm diameter cap without crushing the mesh or allowing the plastic to wick past the shut off.

Other than the delicate shut-off around the mesh the other complication with this program was the system to build these parts. It didn't exist. Here's a case where not only was the part complex but so was the custom molding unit that was built to handle the process. It's a case where the customer's ideal was an integrated component and the solution was a custom built injection unit to make it happen.

Case 3:

Here's an example of pushing the limits with insert molding. The larger part, about 1.5" long, is an extremely complex molded part with 3 independent metal inserts. The smaller part on the top has 5 discreet inserts.

The challenge, especially with the larger part, was combining the mold design with all of the different core-pulls, side-actions and shut-offs so the customer would have one integrated component instead of two or three separate parts. It was a case where their ideal took great collaboration to accomplish.




Case 4:

This part is approximately a 4mm diameter PEEK lead frame part. The part is overmolded on the lead strip then post-mold singulated and die-formed to its final shape.

As we discussed, PEEK isn't the friendliest when it comes to thin wall sections. The challenge here was processing this part in a lead frame environment to achieve the 0.25mm thin center. This delicate part then is loaded in custom trays to protect it while in transport to our customer's assembly location.

Hopefully keeping these five things in mind when approaching your next micro molded project will help you push the limits and make your next design a success. There can be many roadblocks along the way. Seek out your experts and who knows… the sky is the limit!

For more information contact Accumold at micromolding@accu-mold.com or +1 515-964-5741.

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