General Molding: preferred design Guidelines as published by Protomold:

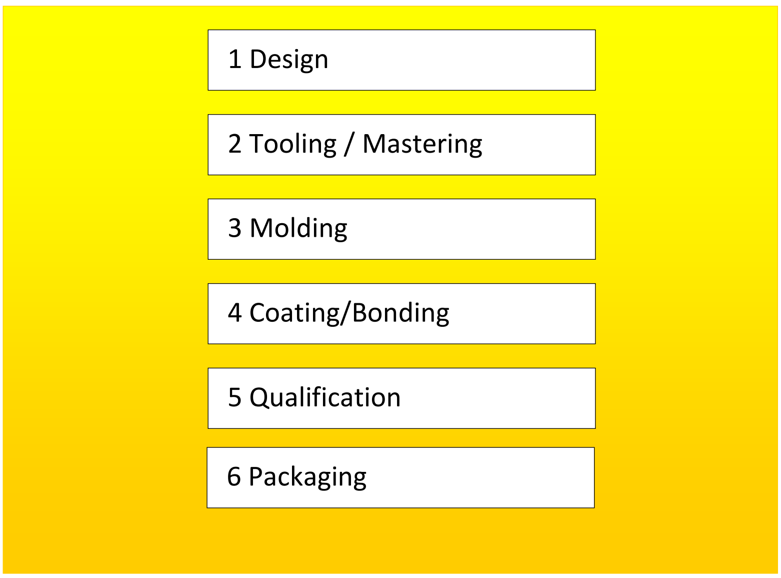
http://www.protomold.com/DesignGuidelines.aspx

Sony Polymer Microstructure Molding guidelines:

Injection molding is a technique for the manufacturing of polymer components. Molten polymer is injected at high pressure into a mold, which is the inverse of the desired component. Injection molding is very widely used for manufacturing a variety of components, from the smallest component for the watch industry to entire body panels of cars. It is the most common method of production polymer components. Normally, polymers are cost efficient and the cycle time to manufacture one component is relatively low. Thus, in many cases injection molding is a low cost manufacturing technique for production of medium to high number of pieces.

The injection molding process described in this handbook is adapted for the manufacturing of components with dimensions of up MTP format (preferably “microscope slide format” or “credit card format”), containing microscopic structures like channels, wells, pillars and holes with typical dimensions in the range of 1µm to 500µm.

The manufacturing process for polymer components comprises following main phases.



In the design phase the concept of the fluidic network has to be transformed into a component design (CAD drawing, 3D model using e.g. SolidWorks) taking into account all requirements and conditions of the molding process. At the end of this phase a complete geometrical and functional description of all needed components is generated. At this stage all mechanical tolerances and material properties should be fixed. Structures will be made with different mastering technologies, dependent on sizes, tolerances and aspect ratio. Most commonly used are micromachining and lithography.

Based on the component design and taking into account the specific requirements of the injection molding process, the necessary molding tools can be prepared. The standard process is using a base tool and mold inserts. If the proposed standard formats are used only the respective mold inserts have to be designed and manufactured for a specific design.

In the molding phase the tool is qualified, the optimal parameter setting for the injection molding process is determined and in a pilot run, a small series of components are fabricated.

After molding surface coatings can be applied using either sputter coating or chemical coating processes. Such coatings may be required e.g. for hydrophilization of the surfaces.

If the channel structures need to be covered by a foil or a solid component various Bonding Processes are available.

During all phases quality checks are done to verify the product and process quality. If necessary, functional tests are carried out to verify the performance of the component (e.g. micro-fluidic chip).

In the last phase the components are packaged into either standard boxes or dedicated packaging (e.g. vacuum pouch).

<u>General design rules:</u>

- Maximum lateral dimension of the molded component (length x width) = MTP format, preferably credit card or MS-Slide 25mm x 75mm
- Maximum overall thickness of the molded component = 5mm (preferably <1.5mm)
- Minimum thickness of the base plate = 0.8mm (remaining thickness “below” structures 0.5mm) – if the molded component is only ca. 25mm x 75mm the minimum thickness can be 0.6mm
- Structures on both sides (upper and lower base area) are possible
- Breakthroughs are possible (min. diameter 0.5mm, preferable 0.8mmm)
- Minimum wall thickness = depending on the aspect ratio, see below
- Distance of structures to component edges = min. 2mm
- Typical tolerances: According to DIN ISO 2768-1 f-fein

<u>Design rules for inserts created by high speed milling:</u>

- Minimum dimension in the plane = 50µm
- Aspect ratio for structures sticking out of the base areas (smallest dimension in the plane / height of the structure) ≤ 1:1

  (if the feature size is smaller than 100µm the aspect ratio should not be ≤ 1:0.5)

- Aspect ratio for structures going into the base area (smallest dimension in the plane / depth of the structure) ≤ 1:2
  (if the feature size is smaller than 10 µm the aspect ratio should not be ≤ 1:1.5)
- Maximum height of a structure = 5mm
- Maximum depth of a structure = maximum thickness of the molded component (but remaining thickness “below” structures 0.5mm)
- Minimum radius at inside corners in the plane = 5µm
- Minimum radius at outside corners in the plane = 30µm
- Minimum distance between two structures = same as structure height but minimum 50µm)
- Stepped structures or ramp structures are possible
- Minimum draft angle 3°, preferably 5°
- Undercuts are not possible

There are possibilities to fabricate structures which are not complying with the design rules – these are general rules only.

<u>Design rules for inserts created by lithography:</u>

- All structures at one side of the molded component either sticking out of the base or going into the base
- Minimum dimension in the plane = 1µm
- Aspect ratio for structures sticking out of the base areas (smallest dimension in the plane / height of the structure) ≤ 1: 0.5)
- Aspect ratio for structures going into the base area (smallest dimension in the plane / depth of the structure) ≤ 1:1.5)
- Maximum height or depth of a structure = 70µm
- Minimum radius at inside corners in the plane = 1µm
- Minimum radius at outside corners in the plane = 5µm
- Minimum distance between two structures = at least same as the either the height or width of the structures (whatever is larger)
- Stepped structures or ramp structures are possible
- Usual draft angle 10° (if there is only one structure height/depth) up to 15° (if there are more than one structure height or ramp structures)
- Undercuts are not possible

There are possibilities to fabricate structures which are not complying with the design rules – these are general rules only.

Typical structures

Microfluidic chips typically are composed of a set of different basic structures in order to realize the required functionality and the basic microfluidic operations (e.g. mixing, separation, transport, splitting, etc.), respectively. In the following, some basic microfluidic structures are listed:

- Channels
- Chambers / Wells / Cavities
- Pillars
- T- or Y-Junctions
- Holes