# Microlens fabrication programme documentation

Half the programme options in this are simple calculations, such as the ROC and focal length, and the others are more complex calculations. This documentation will lay out how each calculation works and what the defined functions do.

## Functions:

**radius\_curvature(r,h)**

*r = radius of lens*

*h = height of lens*

This can be used for any lens which is a spherical cap, and is simply the equation

**Height(r,ROC)**

*r = radius*

*ROC = Radius of curvature of the lens*

This can be used for any lens which is a spherical cap, and is a rearrangement of the equation ->

The minus part of the quadratic solution is used as geometrically, the smaller side of the sphere is required.

**Microlens(ROC,r,x,h,thickness\_diamond)**

*ROC = radius of curvature of the lens*

*R = radius of lens*

*x = x grid created in the main function*

*h =height of microlens*

*thickness\_diamond = the after etch thickness of the diamond, by default this is 0.05 but must be non zero*

This creates an array with the full shape of the diamond microlens and the flat sides.

**Growth\_start(t,x,rate\_resist,rate\_damond,r,y,dt,angle,dx)**

*t = time taken to etch diamond*

*x = x grid array*

*rate\_resist = etch rate for the photoresist*

*rate\_diamond = etch rate for the diamond*

*r = lens radius*

*y = microlens function output*

*dt = delta t*

*angle = radians. for vertical walls, angle = 0, for /-\ angle = positive, for \\_/ angle = negative*

*dx = difference between consecutive x values.*

This reverses the etch of the diamond and photoresist, effectively simulating growing the diamond/photoresist. Start with the microlens shape, and grow the diamond to a flat surface and the photoresist grows on top of this.

First the flat diamond level is found, by iterating the growth of the sections not within the lens as these will only have diamond etching. Then the diamond is grown to the flat section within the lens and the photoresist is grown on top in the extra time. This gives a reasonable approximation for the required photoresist profile, and due to the spherical symmetry, the photoresist shape.

It then takes this shape and integrates it, and then equates the area for the photoresist pillars and the reflowed photoresist (assuming no evaporation), to find the original height of the photoresist, and creates a profile for this shape.

One limitation is that there is no height discrimination, therefore the diamond lens and the photoresist radius are the same, which doesn’t happen in reality.

**h\_height(trunc,dx,x,r,vol\_0,con,h\_0)**

*trunc = iteration at which the process truncates and outputs the value for h0*

*dx = delta x*

*x = x grid*

*vol\_0 = initial volume*

*con = desired level of convergence between volume values*

*h\_0 = original photoresist pillar height*

Iterates an approximation for the shape of the photoresist, assume spherical shape and no evaporation.

**developed(r\_dev, x\_grid,h0)**

*r\_dev = radius of the photoresist pillar*

*x\_grid = x grid*

*h0 = initial thickness of photoresist*

assumes vertical sidewalls and creates the shape of the developed photoresist pillars

## Options:

1. Input the height of the microlens, h, the radius of the lens, r, and output the Radius of curvature of the lens

2) Input the RoC, lens diameter to give the height of the microlens

3) Input the RoC, height and radius of the microlens to find the thickness of photoresist required.

4) Input the photoresist height and reflow temperature and get the maximum possible diameter of the microlens as the output

5) Input the photoresist thickness, diameter to find the height/shape of the reflowed photoresist and the ROC, height and the minimum etching time to get the lens

6) Input 2/3 of ROC, height and diameter of the lens, find the focal length and NA of the diamond microlens

7) Input the desired ROC and diameter of the lens, get the minimum necessary h0, the minimum etch time, the minimum reflow temp, and the shape of the reflowed PR and lens

8) Input the desired focal length and reflow temperature and get the required lens radius and height.

9) Input h0, r\_t, r\_b, r\_reflow, h\_reflow, r\_lens, h to get shape on graph and evaporation percentage

10) Input the d and h0 to find the minimum reflow temperature