Forecasting the thickness distribution of the evaporated material

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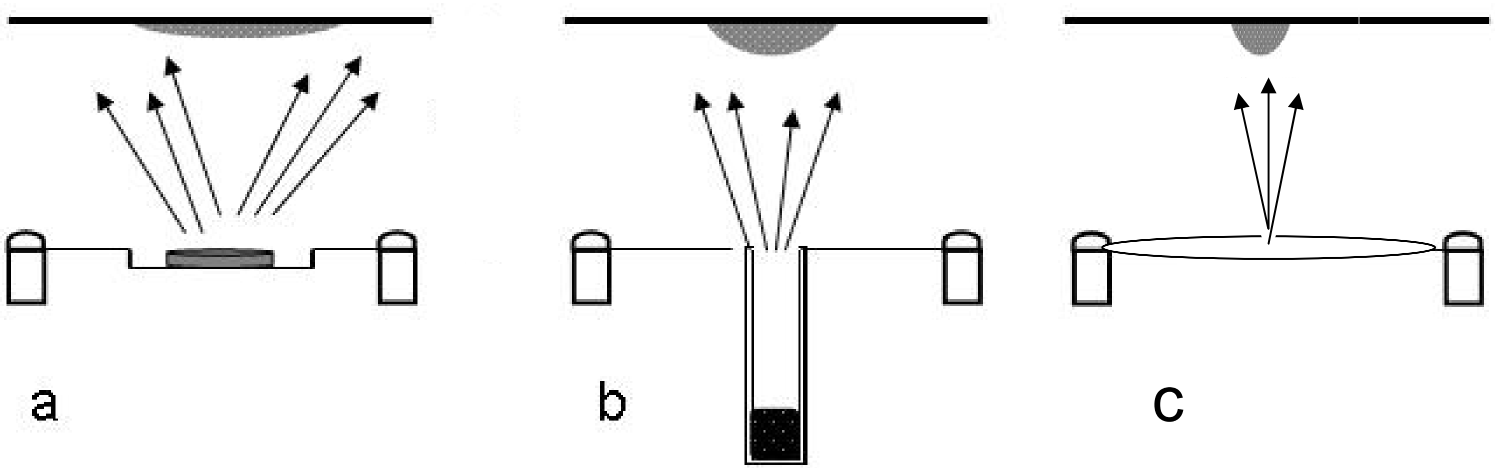
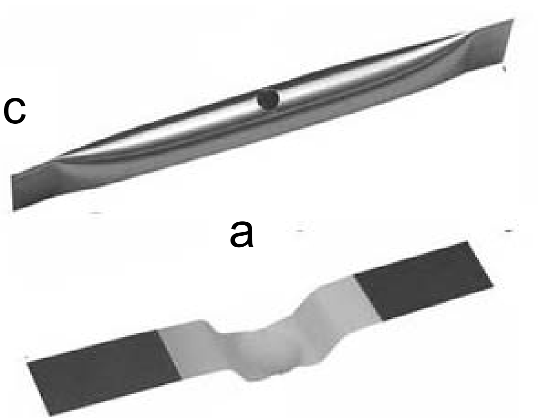
Challenge:

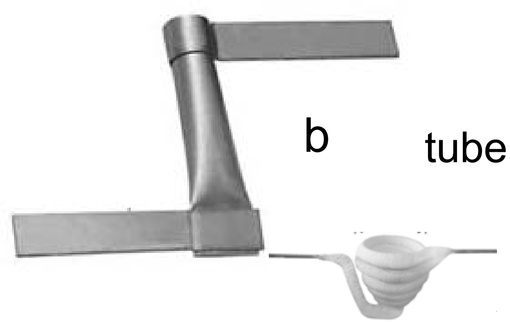
preparation of the target with acceptable thickness inhomogeneity with minimal material loss



pin-hole boat

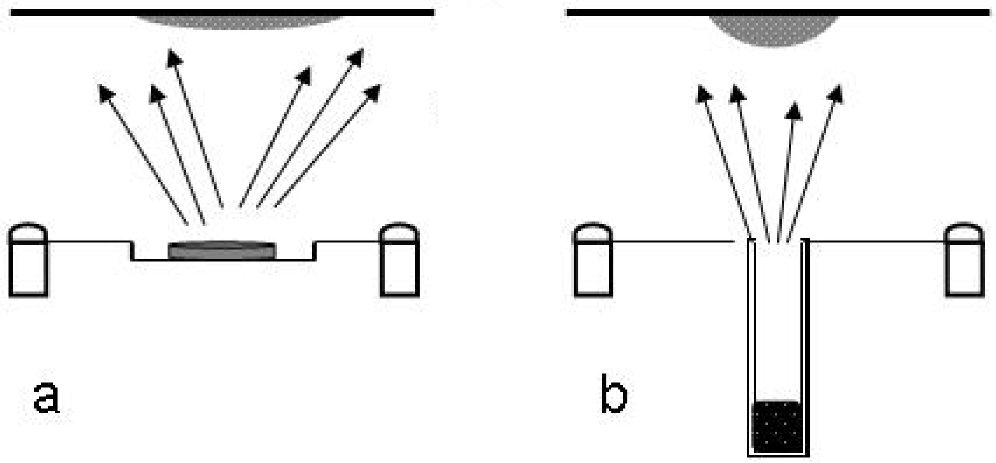


open boat



b

tube or V shaped boat



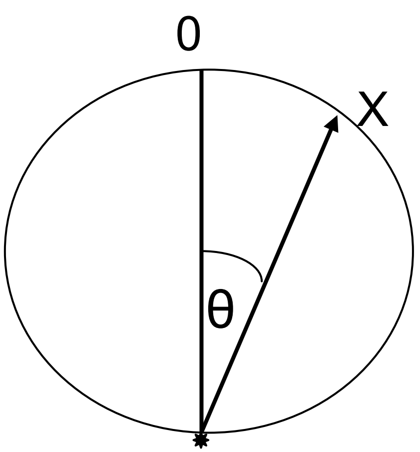
Can the shape of the ‘stalactite’ be foreseen?

The thickness fluctuation/material distribution can be predicted based on the flux distribution cosine law. Also known in optics as Lambert law.

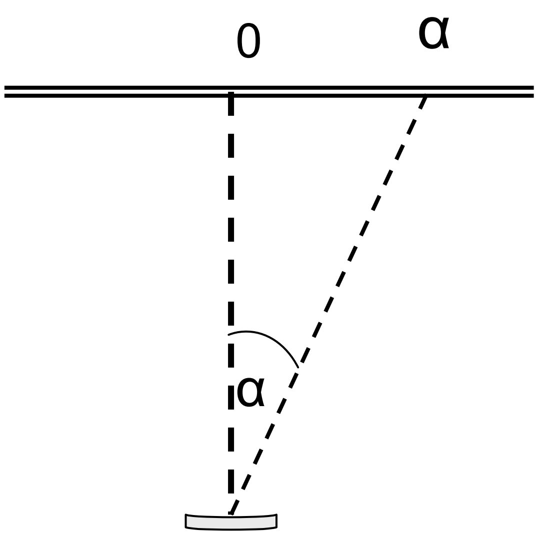
The law defines the light intensity at a point x on the illuminated surface as proportional to the cosine of the angle between the normal to the source and the incident light ray. For a point light source the light intensity at the point x is described by:

$$I_x = I_0 \times \cos\theta \qquad (1)$$

where I_0 is the intensity of the light flux emerging from the source and $\cos\theta$ is the cosine of the angle between the normal to the source surface and the incident light ray.



Similarly to the light intensity, the amount of the deposited material at point α depends on the vapour stream intensity emerging from the point source.

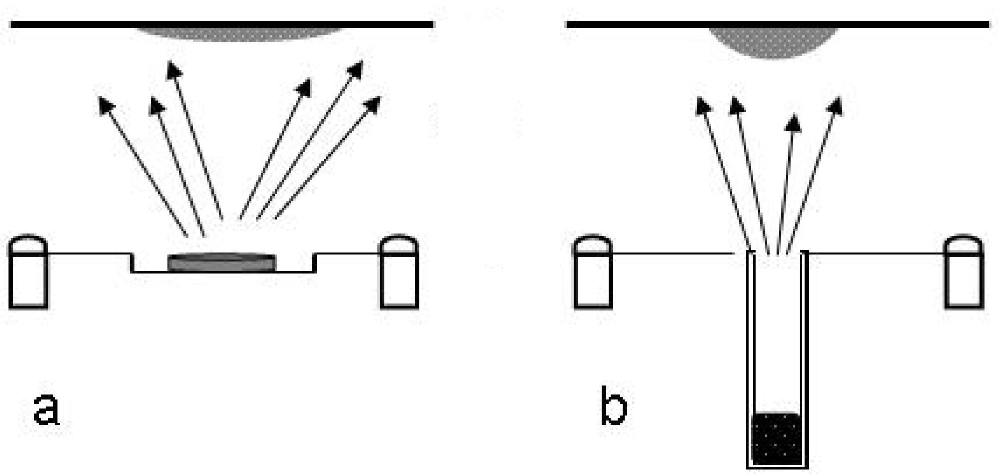


$$M(\alpha) = M(o) \times \cos \alpha \qquad (2)$$

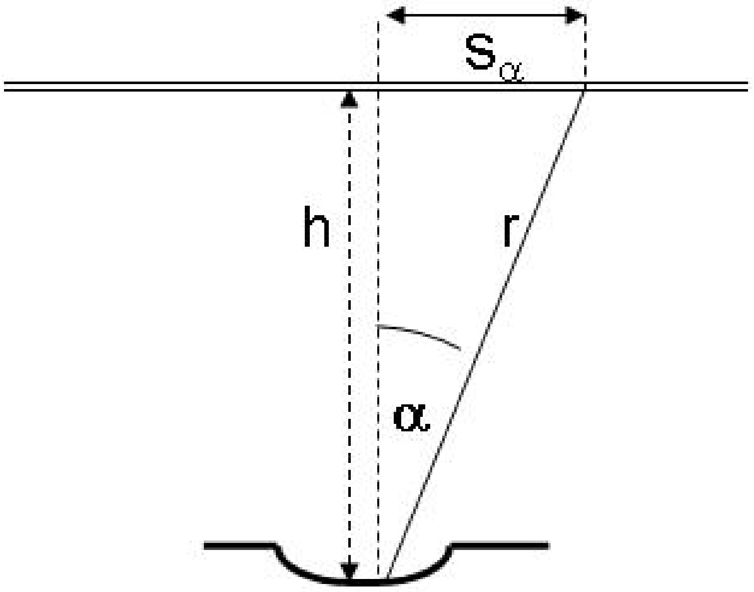
where M(α) and M(o) are the material vapour intensities/amounts at the angles α and 0, So, the deposit thickness variation between the centre and the border of the deposit for deposition on a flat substrate may be forecasted applying equestion:

$$d(\alpha) = d_0 \times \cos^{n}\alpha \qquad (3)$$

where d(α) and d_0 are the deposit thickness at angles α and 0, n ≥ 1 depends on the vapour source type and has to be determined experimentally.



Taking into account the geometry parameters of the evaporation set-up and trigonometry $\cos\alpha = h / r$

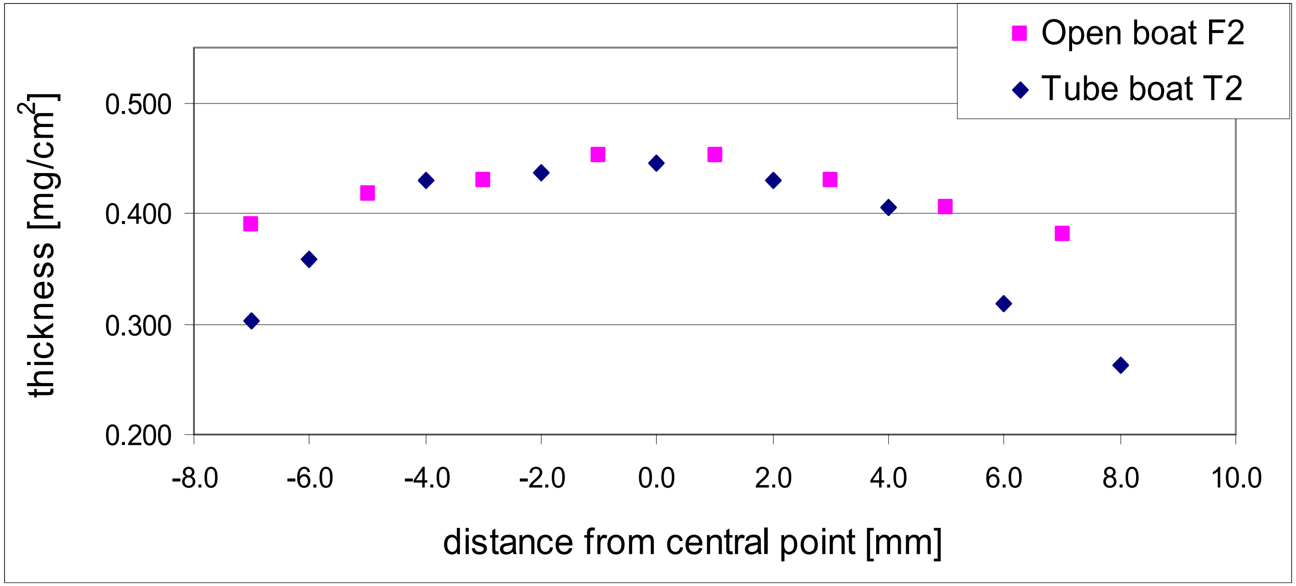


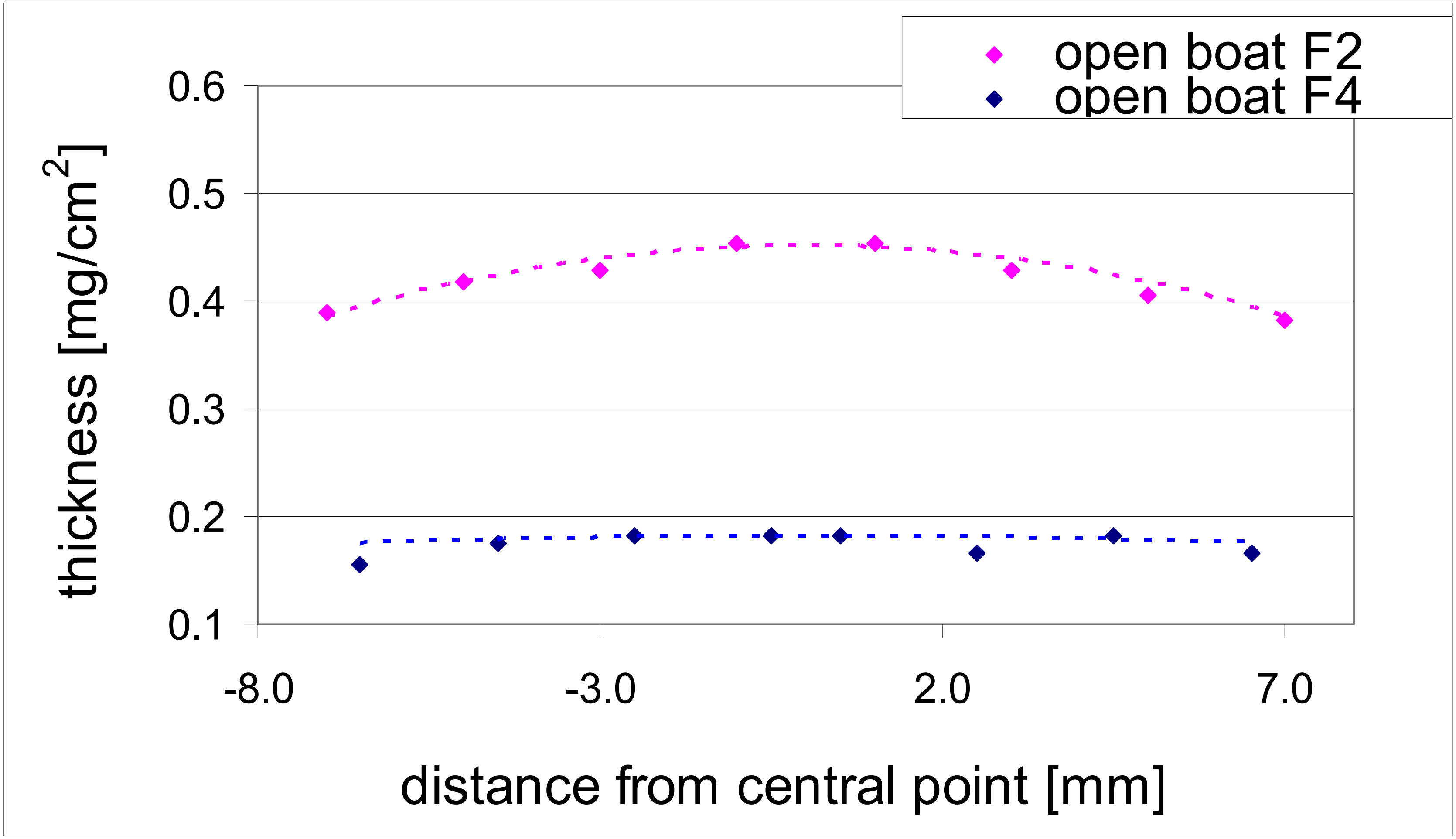
$$r = \sqrt{(S\alpha^2 + h^2)}$$

$$d(\alpha) = d_0 \left[h/\sqrt{(S_\alpha^2 + h^2)} \right]^n \qquad (4)$$

or

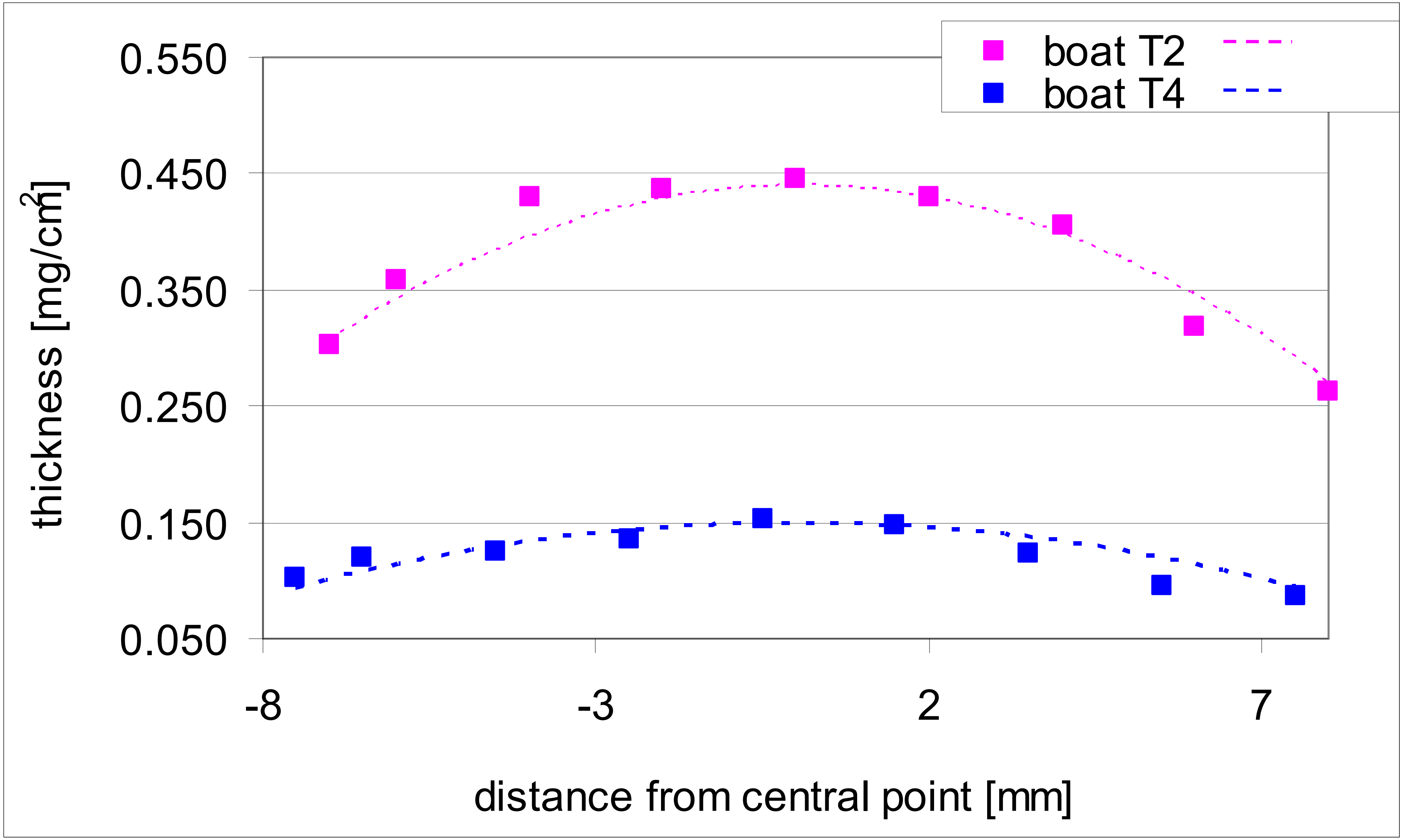
$$d(\alpha) = d_0 \left[1 + (S_\alpha/h)^2 \right]^{-n/2}$$


Open boat F2
Tube boat T2
thickness [mg/cm2]
0.500
0.400
0.300
0.200
-8.0
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0
8.0
10.0
distance from central point [mm]

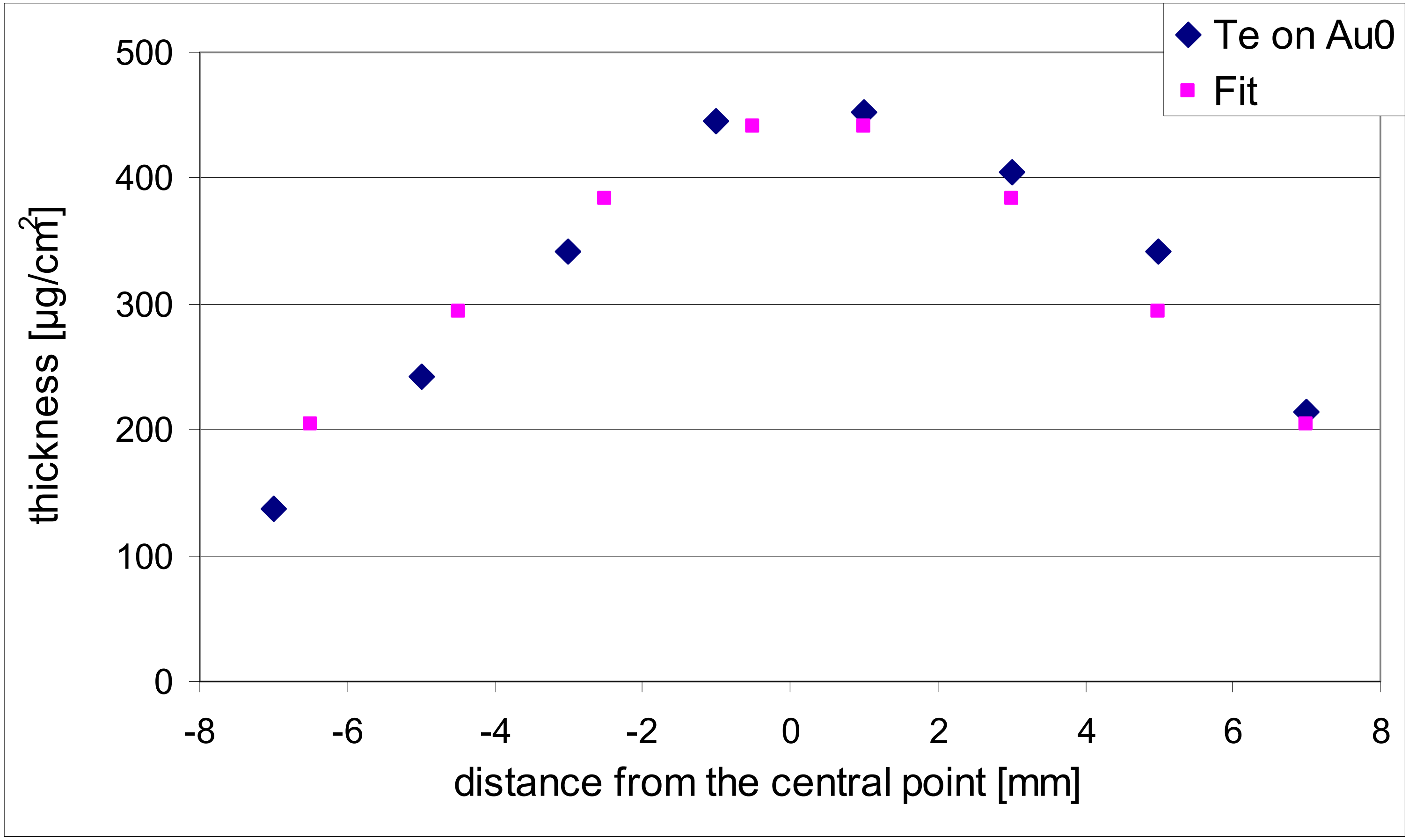

open boat F2
open boat F4
0.6
0.5
0.4
0.3
0.2
0.1
thickness [mg/cm²]
-8.0
-3.0
2.0
7.0
distance from central point [mm]

h = 2 and 4 cm

n = 3

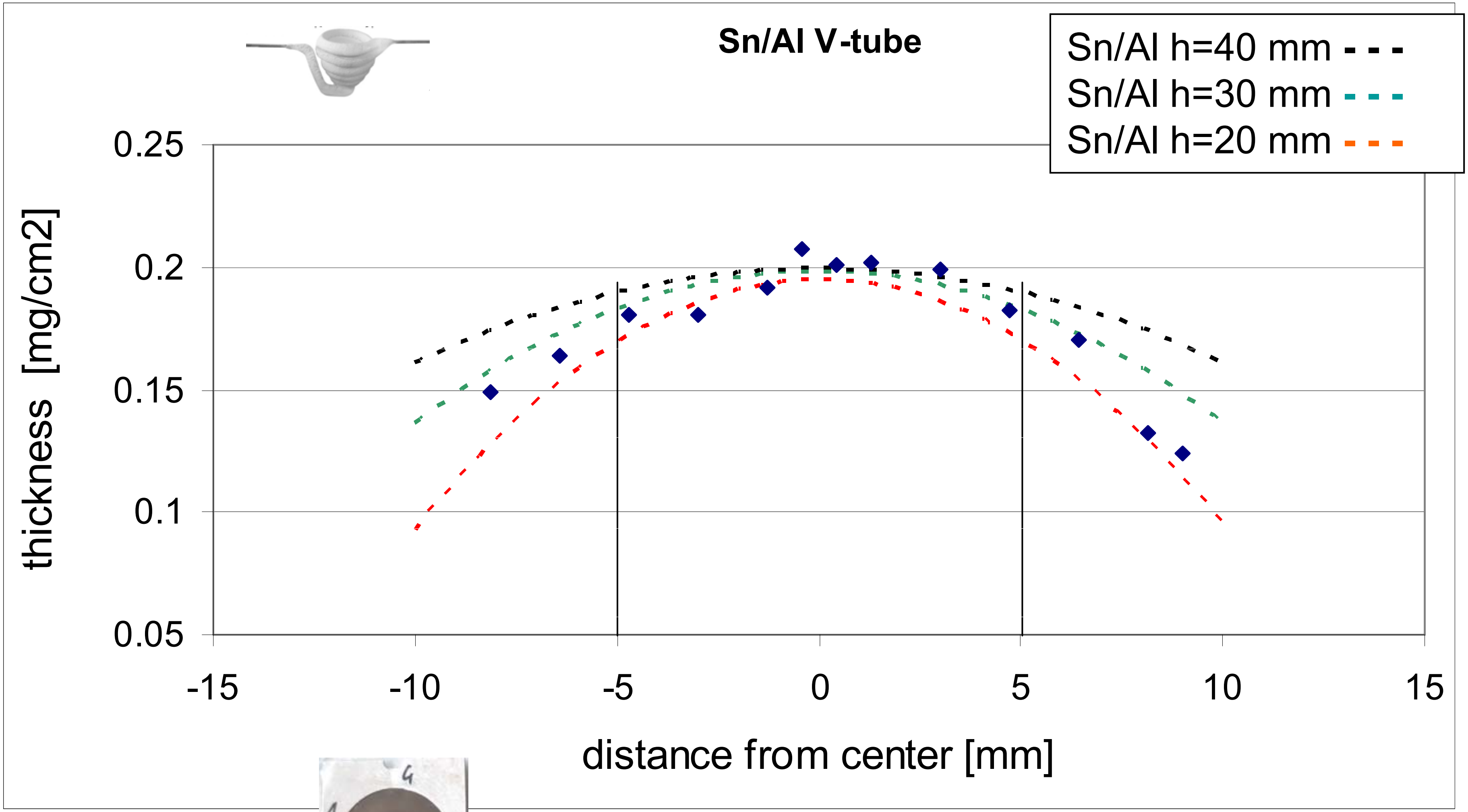

boat T2
boat T4
0.550
0.450
0.350
0.250
0.150
0.050
thickness [mg/cm2]
-8
-3
2
7
distance from central point [mm]

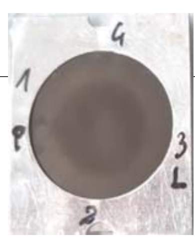
h = 2 or 4 cm n = 7

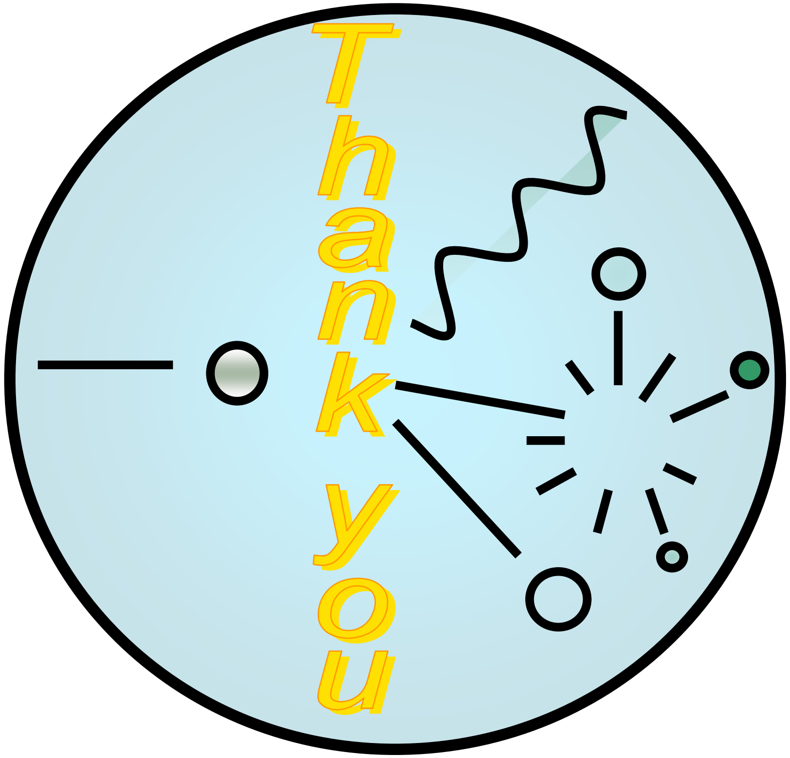


Te on Au0
Fit
500
400
300
200
100
0
-8
-6
-4
-2
0
2
4
6
8
thickness [μg/cm2]
distance from the central point [mm]

h=1.8 cm


Sn/Al V-tube
Sn/Al h=40 mm
Sn/Al h=30 mm
Sn/Al h=20 mm
0.25
0.2
0.15
0.1
0.05
thickness [mg/cm2]
-15
-10
-5
0
5
10
15
distance from center [mm]


4
1
P
3
L
2


Thank you