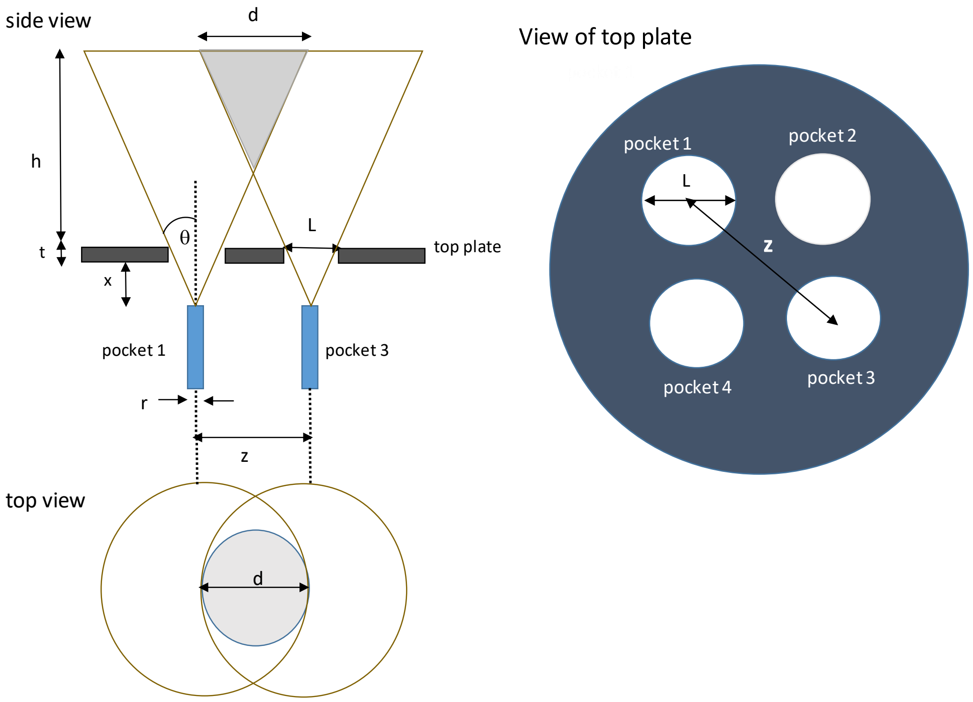
EVAP-4 Technical Note

Evaluating Working Distance Parameters for the High Capacity Four Pocket Mini E-Beam Evaporator (EVAP – 4)

When optimizing the working distance for thin film deposition using the High Capacity Four Pocket Mini E-Beam evaporator (EVAP – 4), several critical factors must be considered, including the required deposition rate and the maximum heat load that the sample can withstand. These parameters are influenced by the choice of evaporant material, desired layer thickness, and the substrate material. Achieving uniform multilayer deposition or co-evaporation from multiple pockets requires fine-tuning of the working distance to ensure that the evaporation cones from each pocket overlap effectively on the substrate. This overlap, which increases with the working distance, is influenced by the geometry of the source and the dimensions of the rod or crucible being used. This technical note presents the calculations for the overlap distance and overlap area for the standard High Capacity Four Pocket Mini E-Beam (EVAP – 4) system, equipped with a rod, offering valuable insights into the optimal configuration for uniform deposition.

Experimental Calculations

A schematic of the pocket and evaporation cone geometry is presented in Figure 1. The individual pocket's evaporation cone is defined by several key parameters: the rod diameter (r), the distance from the top of the rod to the top plate (x), the top plate thickness (t), and the top plate opening (L). Standard parameters for the High Capacity Four Pocket Mini E-Beam (EVAP – 4) system are provided in the accompanying table. The overlap diameter (d) of the evaporation cones for two diagonal pockets was calculated as a function of the working height (h), using a standard 27 mm length rod. Results are presented for both a 4 mm rod and a 2 mm rod (which can be fitted with a Mo collar). The overlap area (A) was estimated by calculating the area of a circle with a diameter equal to the calculated overlap diameter (d), as depicted in Figure 1. These calculations provide the foundation for understanding the impact of rod geometry and working distance on deposition uniformity.



Parameter	Value
x	3 mm
t	3 mm
z	31 mm
L	16 mm

Figure 1: Geometry of the pocket and evaporation cone for the High Capacity Four Pocket Mini E-Beam (EVAP – 4).

Results

The overlap distance (d) as a function of working height for the High Capacity Four Pocket Mini E-Beam (EVAP – 4) system is shown in Figure 2, with results for both 2 mm and 4 mm diameter rods. As expected, the overlap distance increases linearly with working height. Notably, moving from a 2 mm rod to a 4 mm rod reduces the overlap diameter by approximately 33 mm (15.2%) at a working distance of 100 mm, with the proportional difference decreasing at larger working distances. For uniform coating of substrates up to 4" (101.6 mm) in diameter, a working distance of 50 mm is sufficient for the 2 mm rod, while a 60 mm working distance is required for the 4 mm rod.

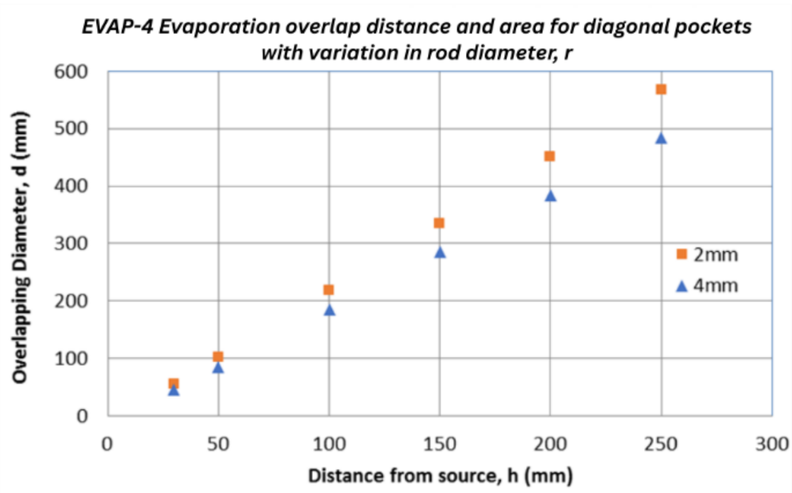


Figure 2: Overlap distance (d) as a function of working height for the High Capacity Four Pocket Mini E-Beam (EVAP – 4) with 2 mm and 4 mm

The overlap area (A) as a function of working distance for both rod sizes is plotted in Figure 3. Since the overlap area depends on the square of the overlap distance, the difference between the 2 mm and 4 mm rods is much more pronounced. At a working height of 100 mm, the 4 mm rod results in a 28% smaller overlap area compared to the 2 mm rod.

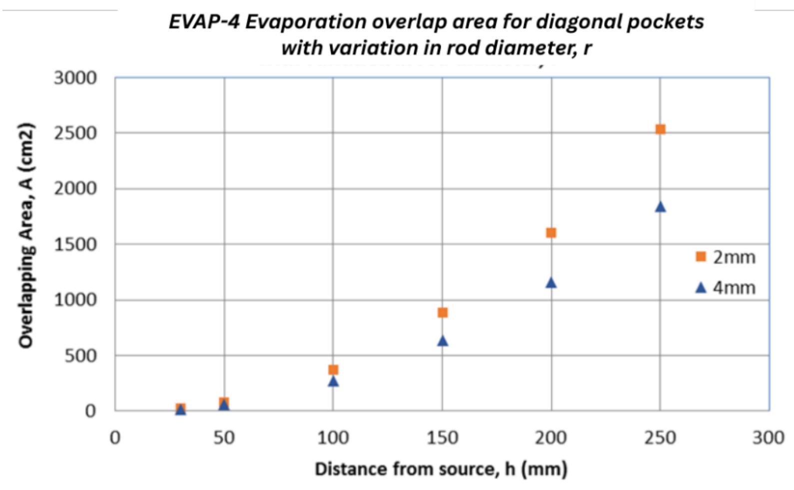


Figure 3: Overlap area (A) as a function of working height for the High Capacity Four Pocket Mini E-Beam (EVAP – 4) with 2 mm and 4 mm rods.

Additionally, variations in overlap distance and area were calculated with different rod-to-top plate distances (x) to estimate the effect of slight rod length or placement changes within the pocket. Figure 4 shows the evaporation overlap distance (d) for a 2 mm diameter rod, with a ±1 mm vertical variation in rod placement for x = 2 mm, 3 mm (standard distance), and 4 mm. A 1 mm shift in the rod position leads to a significant change in the overlap diameter. Moving the rod tip closer to the top plate (x = 2 mm) results in a 21% (47 mm) increase in overlap diameter at a working distance of 100 mm, while moving the rod further back (x = 4 mm) gives a smaller 15% (33 mm) reduction in overlap diameter.

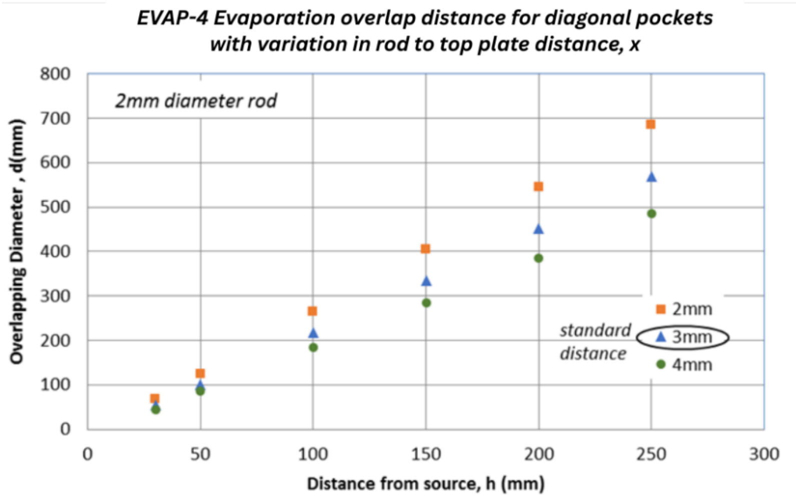


Figure 4: Overlap distance (d) as a function of working height with varying vertical rod placement (x).

The overlap area (A) corresponding to these shifts in vertical rod placement is plotted in Figure 5. At a working distance of 100 mm, moving the rod 1 mm closer to the top plate (x = 2 mm) results in a 47% increase in overlap area, while moving the rod 1 mm further away (x = 4 mm) leads to a 28% reduction in overlap area. These data highlight the sensitivity of the evaporation cone to small changes in rod placement and vertical height, underscoring the importance of precise positioning for optimal deposition uniformity.

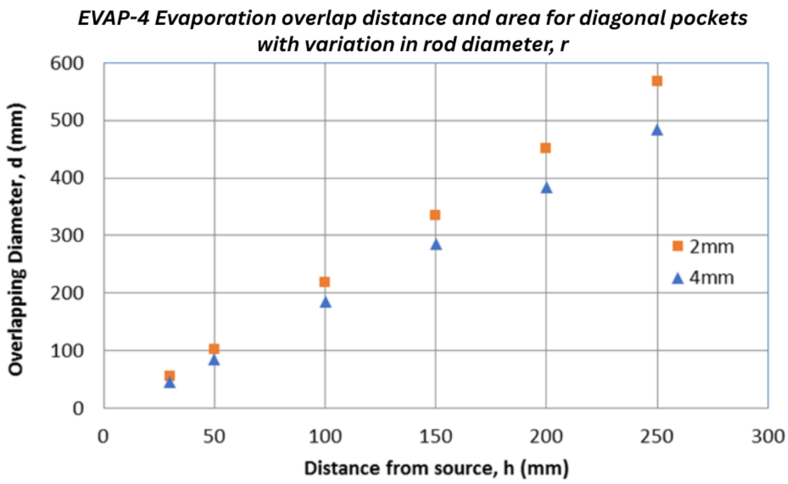


Figure 5: Overlap area (A) as a function of working height with varying vertical rod placement (x).

Conclusion

The calculations highlight that both the overlap distance and overlap area are highly sensitive to small changes in geometry, such as variations in rod diameter or length. For the current research project, the key positive takeaway is the ability to precisely monitor and adjust the rod-to-top plate distance as the rod is consumed during the evaporation process. By understanding this gradual increase in distance, the research team can effectively predict the reduction in overlap distance and area over time, allowing for proactive adjustments to maintain deposition uniformity.

Furthermore, these results enable the researcher to estimate the initial overlap area based on the starting rod length and diameter, providing a clear upper limit for optimal deposition. This information is crucial for minimizing material wastage and optimizing the evaporation process, particularly in relation to the increasing shadowing effect of the top plate as the rod shortens. This analysis supports more efficient material usage and helps to maximize the effectiveness of the deposition system throughout the lifetime of the rod.