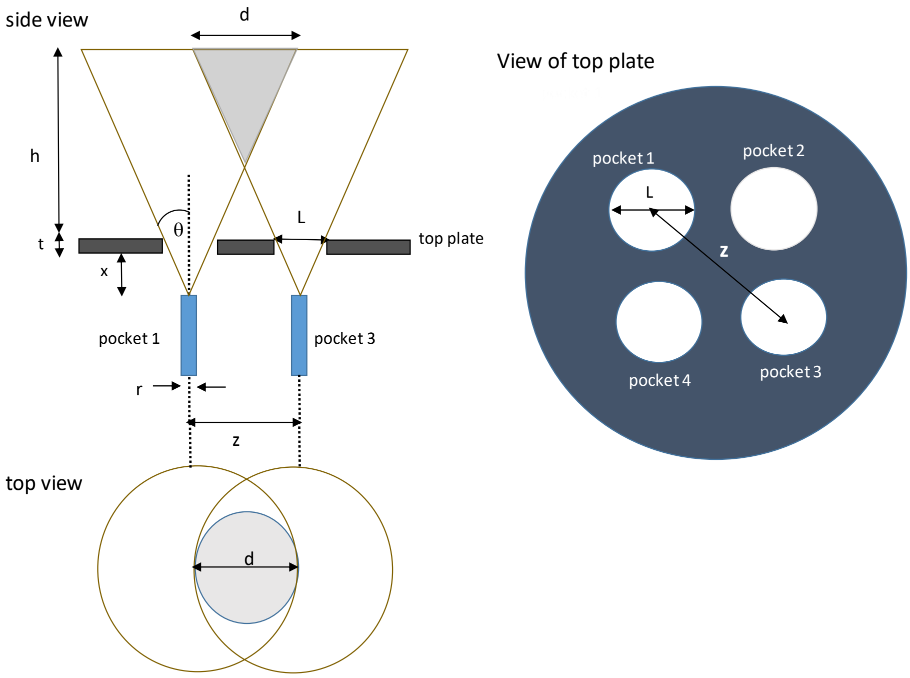
EVAP-4 Technical Note

Evaluating Working Distance Parameters for the Compact Four Pocket Mini E-beam Evaporator (EVAP – 4C)

When determining the optimum working distance for thin film deposition using the Compact Four Pocket Mini E-beam Evaporator (EVAP – 4C) several key factors must be considered, including the required deposition rate and the maximum heat load on the sample. These parameters are influenced by the evaporant material, the desired layer thickness, and the substrate material. Achieving uniform multilayer deposition or co-evaporation from multiple pockets requires precise alignment, as the working distance must be optimized to ensure that the evaporation cones from each pocket effectively overlap on the substrate. This overlap increases with the working distance, and its extent is governed by the geometry of the source and the dimensions of the rod or crucible. This technical note outlines the calculation of the overlap distance and overlap area for the standard Compact Four Pocket Mini E-beam Evaporator (EVAP – 4C) equipped with a rod, providing essential insights for users aiming to optimize their deposition setup.

Experimental Calculations

The geometry of the pocket and evaporation cone is illustrated in Figure 1, where the individual pocket's evaporation cone is influenced by several 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). For the standard Compact Four Pocket Mini E-beam Evaporator (EVAP – 4C), these parameters are specified in the accompanying table. The overlap diameter, d, of the evaporation cones from two diagonal pockets was calculated by considering the working height, h, for a standard 27 mm rod length. The calculations were specifically carried out for a rod with a 2 mm diameter. The overlap area, A, was estimated as the area of a circle, where the diameter of the circle corresponds to the calculated overlap diameter, d, as depicted in Figure 1. This approach allows for an assessment of the effective deposition region and is critical for optimizing multilayer or co-evaporation processes.



Parameter	Value
x	5 mm
t	3 mm
z	17 mm
L	8 mm

Figure 1: Geometry of the pocket and evaporation cone for the Compact Four Pocket Mini E-beam Evaporator (EVAP – 4C).

Results

The overlap diameter and overlap area for Compact Four Pocket Mini E-beam Evaporator (EVAP – 4C), are plotted as a function of working distance in Figure 2. The plot confirms that the overlap diameter increases linearly with working height, as expected. Additionally, the overlap area follows a quadratic dependence on the overlap diameter, and consequently, on the working distance. For uniform co-deposition, the minimum working distance required for a 2" (50.8 mm) wafer is 80 mm, while for 3" (76 mm) and 4" (101 mm) wafers, the minimum working distances increase to 115 mm and 150 mm, respectively.

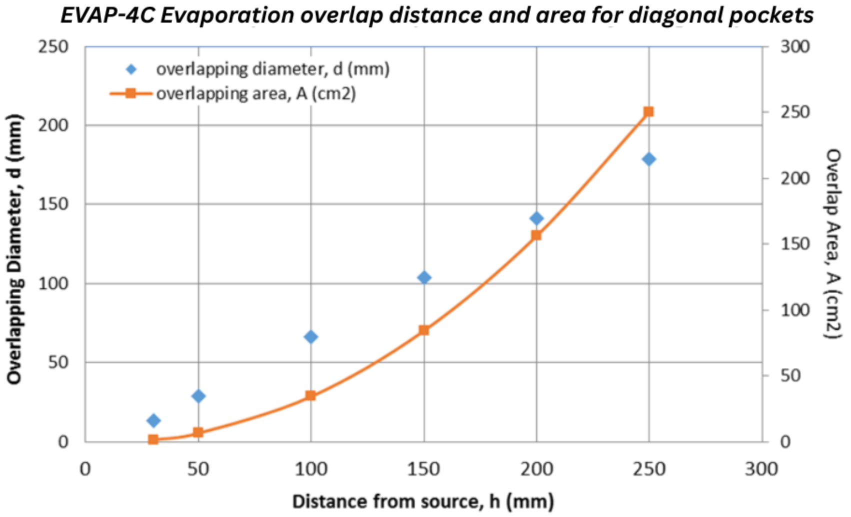


Figure 2: Evaporation overlap diameter (d) and overlap area (A) as a function of working distance for a 2 mm rod.

Further calculations were made to examine the effect of slight variations in rod length or rod placement inside the pocket. Figure 3 presents the variation in overlap distance, d, for a 2 mm diameter rod with a ±1 mm change in vertical rod placement, considering distances x = 4 mm, x = 5 mm (standard distance), and x = 6 mm. At a 100 mm working distance, a shift in the rod position by +1 mm closer to the top plate (x = 4 mm) results in a 10 mm or 16% increase in overlap diameter. Conversely, a -1 mm shift further from the top plate (x = 6 mm) results in an 8 mm reduction in overlap diameter (-12%). This implies that, for a 3" wafer, a 1 mm shift in rod placement (from x = 5 mm to 6 mm) increases the minimum working distance required for co-evaporation from 115 mm to 130 mm.

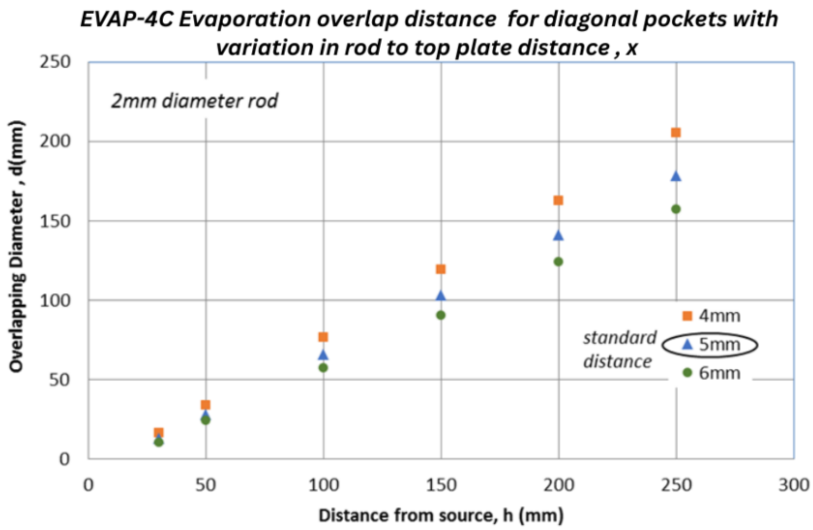


Figure 3: Evaporation overlap distance (d) for a 2 mm rod with varying vertical rod position (x).

The overlap area corresponding to the same ±1 mm variation in rod placement is shown in Figure 4. Due to the quadratic dependence of the overlap area on the overlap distance, a ±1 mm shift in rod position leads to a more significant change in the overlap area. Specifically, for a 100 mm working height, moving the rod 1 mm closer to the top plate (x = 4 mm) increases the overlap area by 35%, while shifting the rod 1 mm further from the top plate (x = 6 mm) reduces the overlap area by 23%. These findings emphasize the sensitivity of the overlap area to slight variations in rod positioning, highlighting the importance of precise rod placement for uniform deposition.

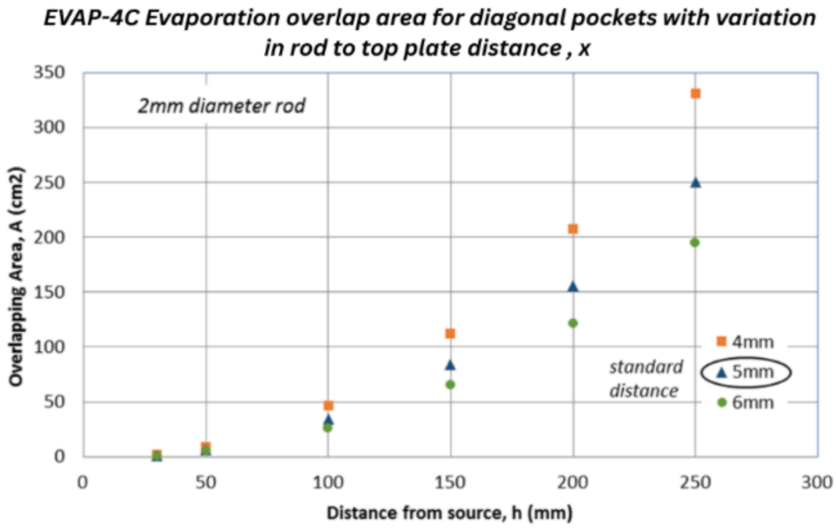


Figure 4: Evaporation overlap area (A) for a 2 mm rod with varying vertical rod position (x).

Conclusion

The calculations demonstrate that both the overlap distance and overlap area are highly sensitive to small changes in geometry, particularly with respect to rod diameter and length. For the current research project, a key positive implication of these results is the ability to accurately estimate and optimize the initial overlap area based on the starting rod length and diameter, providing a reliable upper limit for uniform deposition. As the rod is consumed during evaporation, the gradual increase in the rod-to-top plate distance will result in a predictable, steady reduction in the overlap area, allowing for proactive adjustments to maintain deposition quality. This analysis also highlights the potential for reducing material wastage, as the shadowing effect of the top plate increases with the shortening of the rod. By accounting for these changes, the researcher can better manage material usage and improve deposition efficiency.