Visualizing precursor flow during ALD processes

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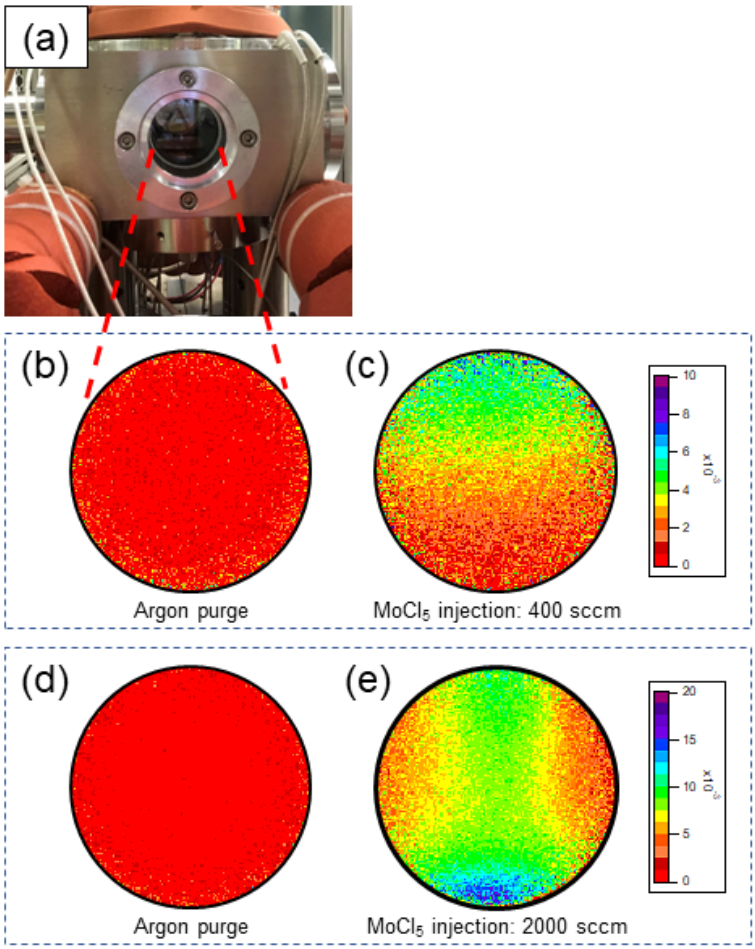

One set of flow visualizations was performed using $MoCl_5$ as the precursor in a research grade ALD chamber, shown from the side in Figure (a) with a 50 mm diameter window in the center of the image. In this chamber, gas was injected vertically from the top from four lines and impinged on a wafer surface parallel to the wafer surface normal. $MoCl_5$ was introduced through one line from a flow over vessel using an argon carrier gas while the other three lines carried only argon. $MoCl_5$ absorbance measurements were performed in transmission through two windows [see Figure (a)] mounted on opposite sides of the chamber. When only argon is flowing, no $MoCl_5$ absorbance (within the noise) was observed, as illustrated in Figure (b) which shows the view through the window. The flow conditions were 100 sccm through each line with a chamber pressure of 1.4 Torr. During $MoCl_5$ injection under these conditions, a relatively uniform $MoCl_5$ absorbance front approaches the wafer chuck as flow sets up in the chamber, as illustrated in Figure (c) which was recorded 320 ms after the $MoCl_5$ injection valves were opened. This behavior contrasts with that observed when flowing 500 sccm through each line with a chamber pressure of 15 Torr. While the $MoCl_5$ absorbance is still zero during the argon purge, as illustrated in Figure (d), a $MoCl_5$ jet is observed in the chamber during precursor flow, as illustrated in Figure (e) which was recorded 150 ms after $MoCl_5$ injection. This example demonstrates the utility of precursor flow visualizations when optimizing deposition conditions.