Implementing Interferometry in Impurity Incorporation Investigations

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Purpose:
As impurities in pharmaceutical drugs become more of a popular center of study, visual methods of identifying how they incorporate themselves into a host are scarce, expensive, or otherwise a hassle to use. The design, assembly, and modification of this experimental laser system allows for the easy modeling of boundary layers to study effects of impurity incorporation during crystal growth/dissolution.

Methods:
The setup utilizes two main components: the Mach-Zehnder interferometer and the flow cell. The interferometer is a treated laser that splits into two paths to generate constructive and destructive interference. The flow cell is a homemade pipe-in-pipe chamber that employs cooling crystallization to grow a single suspended crystal. The cell is intended to sit in the lasers path, allowing the fluid and crystal to change the interference of the laser beam. Its design allows for quick cycle times between runs and easy access to the center chamber.

Results:
During experimental runs with an empty flow cell, it visibly outputs a magnified pattern of perfect vertical interference fringes. These bars can be imaged and studied with precision through pixel counting. When the flow cell contains a crystal in a saturated solution, seeing shifted interference fringes and curved vertical lines is expected. This curvature has the potential to be modeled (reverse engineered) to reveal the concentration gradient of the fluid around a selected surface of the crystal during growth/dissolution, thus defining a unique boundary layer for the impure and pure region of the crystal.

Conclusions:
In this case, once a concentration gradient is obtained, it can reveal which incorporation mechanism (i.e. mass transfer or interfacial kinetics) dominates under different crystallization conditions (supersaturation, temperature, mixing, etc.), potentially revealing the relationship between the impurity and host adherence to the crystal surface. The setup's simple and compact nature provides potential for it to be used in laboratory settings for a wide array of investigations that surround crystal growth/dissolution, not just for drug impurity purposes.

Keywords:
Interferometry, impurities, pharmaceuticals, modeling, imaging