**Experimental Objectives**
- Investigate microwave plasma assisted chemical vapor deposition (MPACVD) single crystal diamond (SCD) growth in a pocket substrate holder.
- Investigate SCD growth versus the pocket holder depth while the reactor is operating at a constant pressure of 240 Torr and at a constant substrate temperature of ~1020 °C.
- Develop a SCD growth recipe versus growth time which produces a PCD rimless SCD.
- Characterize the grown SCD substrates.

**Background**

**Diamond Material**

Single crystal diamonds (SCD) exhibit exceptional and unique properties which are promising for several applications, such as, optical, mechanical and high-power electronics.

**Experimental Reactor:** microwave cavity plasma reactor (MCPR)

The experimental variables:
- **Variable Input variables:** Incident Power, \( P_{inc} \); \( P_{inc} \) is held constant as the deposition time increases, then \( T_d \) increases versus time. This is because as diamond deposition proceeds the CVD SCD volume increases, and grows into the discharge. Also other characteristics change versus time, i.e., a PCD rim form on the substrate holder. These changes versus time result in a varying reactor operating curve versus time. See Curve 2.
- **Fixed Input variables:** Pressure, \( p=240 \) Torr; Total flow rate: 420 sccm (5% CH4/H2); Residual nitrogen < 20 ppm.

**Big Challenges Ahead**

- **High Quality:** Crystal defects, Optical absorption
- **High Quality:** Robust optical properties
- **Large Area:** Thick polycrystalline (PCD) rim growth
- **Solution (new holder design by MSU):**

**Experimental Results**

**SCD growth versus pocket holder depth**

| Pocket holder: 2.3 mm | Area gain: 1.78 times | Growth rate: 28 μm/h |
| Pocket holder: 2.9 mm | Area gain: 1.38 times | Growth rate: 29.1 μm/h |

**Influence of the pocket depth on the lateral surface**


**Optical Microscope and SEM Analysis**

Optical microscopy and SEM images of all substrates exhibit a smooth top surface and no evidence of PCD rim.

**Summary**

A MPACVD growth recipe was developed to grow PCD rim free SCD, \( T_d \) was held approximately constant at 1020 °C, and the process was stopped when the SCD grew out of the pocket. The PCD rim was eliminated for all pocket depths. Under the constant pressure and \( T_d \) conditions the normalized lateral area gain decreased as the pocket depth was increased. SIMS analysis shows that Nitrogen concentrations in the diamond are < 120 ppm. Birefringence imaging displays low stress in the substrate.

**References**