Laser Induced Plasma for Chemical Vapor Deposition: Theory and Experiment

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A possibility of deposition from laser-induced plasma (LIP) is investigated in search for an economic and simple method to obtain isotopic compounds from enriched gaseous precursors. A breakdown in mixtures of BCl_3 and BCl_3 with hydrogen, argon, and methane are studied both theoretically and experimentally. Calculations of expanding plasma of different composition are performed with the use of the fluid dynamic code[1] coupled to the equilibrium chemistry solver[2]. Condensed phases of boron, boron carbide, and graphite are predicted showing maximum concentrations in peripheral zones of the plasma.

In experiment (Fig.1) LIP is induced in mixtures BCl_3, H_2+BCl_3, H_2+Ar+BCl_3, H_2+BCl_3+CH_4, BF_3, H_2+BF_3, H_2+Ar+BF_3, and H_2+Ar+BF_3. The gases are analyzed before, during, and after laser irradiation by optical and mass spectrometry. The composition of reaction products is found to be close to that predicted theoretically. The conversion of precursor gases BCl_3 and BF_3 into gaseous and condensed products is 100% for BCl_3 and 80% for BF_3. Solid deposits of up to 30 mg are obtained from all the reaction mixtures. FTIR analysis of BCl_3+H_2+CH_4 deposits points to a presence of condensed boron and boron carbide that are also predicted by the model. Both calculations and preliminary experimental results suggest the chemical vapor deposition by LIP is promising for conversion of gaseous enriched precursors into elemental isotopes and their isotopic compounds.

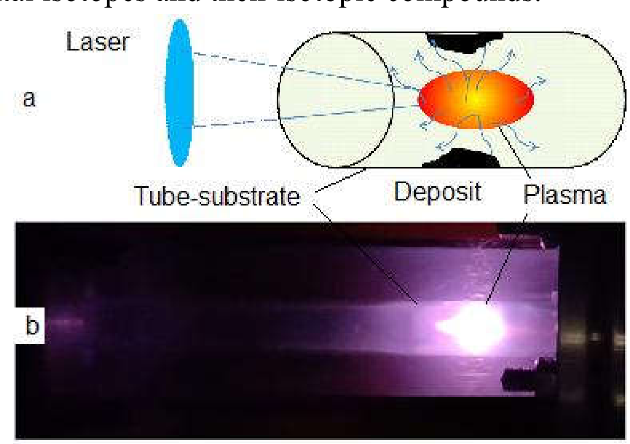

Figure a) schematic of chemical reactor based on laser induced plasma; b) photo of laser induced plasma in H_2:BCl_3 mixture.

1. Shabanov SV, Gornushkin IB (2018) Applied Physics A 124: 716
2. https://cearun.grc.nasa.gov