

5. Vapor Plasma Processes (laser plasma chemistry)

By

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Host: Assoc Prof. Cesare Soci

Abstract

In this talk, we discuss 2 aspects. The first - refers to gas dynamic of vapor plume expansion and pulsed laser deposition. Film-thickness profiles obtained in pulsed-laser deposition are calculated by using the well-known solution of the gas-dynamic equations which describes the expansion of the plasma plume in vacuum. The time for plasma formation is supposed to be short compared with the time of expansion. The film profile depends on the initial dimensions of the plume and on the adiabatic exponent of the vapor. The second problem refers to the condensation of vapor within the expanding plume produced by ns-laser ablation is discussed within the frame of Zeldovich and Raizer theory of condensation. The calculations have been done for the Si vapor. It is shown that the size of clusters formed during the condensation is very small because of fast expansion of the plume and quenching phenomena. The average cluster radius is calculated for different temperatures and densities of initial plume and it is typically of the order of few nanometers. The generalization of the theory is made for inhomogeneous plume where the rates of nucleation as well as condensation times are different for different parts of the plume. As a result, the distribution in cluster's size appears. Nevertheless, this distribution function is very sharp for the plume expanding in vacuum. For the clusters moving together with vapor one can distinguish three different waves propagating through the plume: (1) wave of saturation, where the vapor becomes saturated, (2) supercooling wave where the highest supercooling is reached, and (3) the quenching wave. Parameters for these waves are calculated. The possibility of oscillation phenomena during condensation is discussed.

Short Biography

Boris Lukiyanchuk received his PhD (Physics and Mathematics) from P. N. Lebedev Physical Institute, Academy of Sciences of USSR in 1979 and his Doctor of Sciences from the General Physics Institute, Academy of Sciences of USSR in 1991. From 1970 to 1980, he was affiliated to the Scientific Research Institute at Moscow, Russia. He was also a Professor, Scientific Advisor and Principal Scientist at Data Storage Institute, A*STAR, Singapore from 1999-2018. Currently he is the Professor, Head of the Nonlinear and Extreme Nanophotonics Laboratory, Lomonosov Moscow State University and Visiting Professor at SPMS, NTU. His research interests include interaction of laser radiation with matter, chemical processing with lasers, nonlinear phenomena, self-organization, laser-ablation, theory of nanocluster formation, photomodification in polymers, laser cleaning, plasmonics, metamaterials, nanoscopy, Nanophotonics and nanoparticles with high refracted index. He is a Honorary Professor at Johannes Kepler University, Austria, a recipient of the IES Prestigious Engineering Achievement Awards (2004), President's Science Award, Singapore (2013). He is a member of the Scientific Counsels of Russian Academy of Sciences, SPIE (2000) and OSA (2010). He has supervised >30 PhD students. He has authored 5 monographs and over 300 original research papers till date.