Modeling RLSA CVD Processes in Ar+H2+C2H6 and Dopant Gas

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Abstract

Introduction: The Radial Line Slot Antenna (RLSA[TM]), a planar microwave (2.45 GHz) plasma source, is used in etch and deposition technology [1] , typically in reactive rich gaseous environment. Plasma chemistry is becoming one of the key challenges in current technology. In this paper, we present a two-dimensional axisymmetric model of microwave plasma produced by RLSA[TM] (commercial reactor) and its numerical implementation in the COMSOL Multiphysics® software. We investigated composition, spatial distributions and plasma parameters of the plasma enhanced chemical vapor deposition (PECVD) process in mixture of Ar + H2 + C2H6 + dopant mixture, where either tetramethylsilane (TMS) - Si(CH3)4 or trisilylamine (TSA) - (SiH3)3N were introduced as silicon based precursors. Several surface reactions were considered to explore model into prediction of deposited film composition.

Use of COMSOL Multiphysics: In this work we explored the capabilities of the Plasma Module and COMSOL Multiphysics for investigations of the plasma enhanced chemical vapor deposition (PECVD) process in mixture of Ar + H2 + C2H6 + dopant mixture, where either tetramethylsilane - Si(CH3)4 (TMS) or trisilylamine - (SiH3)3N (TSA) were introduced as silicon based precursors. Increased reaction scheme setting is currently under testing. Compressible flow was coupled with the physics interfaces in the Plasma Module and solved in a self-consistent manner.

Results: Fig.2 illustrates several parameters in plasma at low pressure (<50 mTorr) operation in Ar +H2 mixture. Microwave power is propagating from coaxial inlet into "slow wave structure" above the actual plasma inside reactor. It cannot propagate deeper into dense plasma and actually travels as surface wave around plasma core defined by critical plasma density. Surface plot inside reactor illustrate resistive heating in plasma. Streamlines show flux of charged particles out of the plasma towards the surrounding walls. Fig. 3 illustrates plasma density and electron temperature at 35 mTorr and 3.5 kW MW power. Further we were concentrated on involved chemistry in PECVD and its validation vs. process data.

Conclusion: The comprehensive assessment of particular cases with an immediate access to detailed information are attractive to research and engineering environment. In the course of simulation we were evaluating computational resources and capabilities of such approach within industrial environment. Computational times are sensitive to process conditions, providing fast turnover at reduced pressures and reasonable reaction sets. More robust reaction schemes and

pressures above 100 mTorr are demanding much larger computing resources. On process side this model successfully predicts the spatial distributions of multiple components in complex molecular plasma. On hardware side (semiconductor tool configuration) it gives substantial flexibility to additional modifications of reactor configuration without time-consuming reworks.

Reference

Hirokazu Ueda, Yusuke Ohsawa, Yoshinobu Tanaka, and Toshihisa Nozawa, Japanese Journal of Applied Physics 48 (2009) 126001

Figures used in the abstract

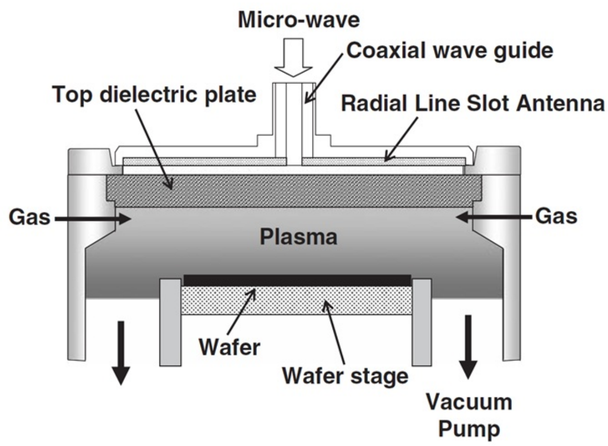

Figure 1: A cross-sectional view of RLSATM PECVD reactor.

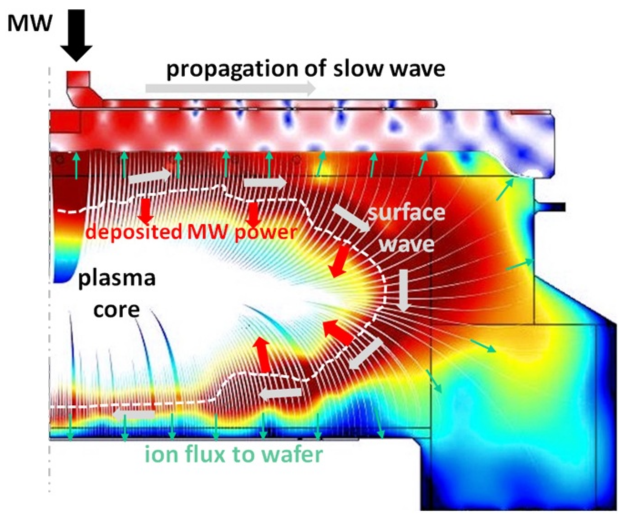

Figure 2: A comprehensive view on processes occurring in RLSATM PECVD reactor. Color range for individual parameters was artificially emphasized to expose the physics inside reactor.

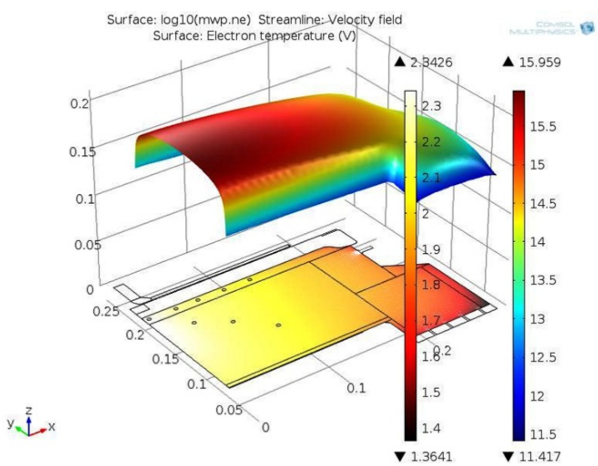

Figure 3: Log of plasma density and electron temperature in Ar+H2 plasma at 35 mTorr.