Fig2. Two dimensional projection of a network (Blue:Si, Red:O) structure. The system exhibits a 3D percolation of aggregates (gelation). This situation can be referred to as “super-aggregation”

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D25: Kinetics of Droplet Motion during Spray Pyrolysis

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Abstract

The deposition of thin films has been performed using a variety of physical and chemical methods. Chemical deposition can proceed using a gas or liquid solution, as exemplified by chemical vapor deposition (CVD) or sol-gel processes, respectively. Spray pyrolysis is a technique which uses a liquid source for thin film coating, first introduced by Chamberlin and Skarman for CdS deposition in solar cell applications [1]. The main advantages of spray pyrolysis are its cost effectiveness, relatively low processing temperatures, and integrability with a CMOS process sequence. Today, the technique is being implemented for the deposition of metal oxide sensing layers [2], yttrium-stabilized zirconia (YSZ) layers for solar cells [3], anodes for lithium-ion batteries [4], among many other applications. The three major steps which are used to describe and model the spray pyrolysis process are: (1) droplet generation through the atomization of the precursor solution, (2) aerosol transport of the droplet, and (3) the droplet evaporation, spreading on the substrate, and decomposition of the precursor salt to initiate film growth. In this study, these three steps are investigated for the deposition of a thin tin oxide (SnO_2) layer for a gas sensor application. The setup required for the process is shown in Fig. 1, where the atomizing nozzle is placed about 30cm away from the heated wafer.

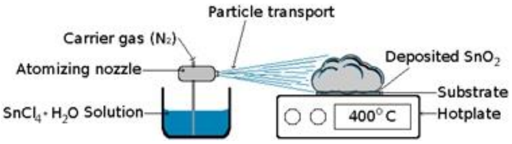

Fig1. Schematic of the experimental spray pyrolysis deposition process as set up for SnO_2 deposition

As the droplet exits the atomizing nozzle, it has an initial velocity which eventually diminishes due to several retardant forces acting on the droplet, including the gravitational, the Stokes, and the thermophoretic forces. With an electrostatic nozzle, as opposed to the pressure nozzle used in this study, an additional electrical force must be included in order to describe the droplet trajectory. We present a model which describes the process of droplet generation and motion during the spray pyrolysis deposition of an SnO2gas sensing layer. An essential step is the modeling of the droplet atomization and generation. The size of the droplet, assumed to be spherical with a radius r, is formed by forcing a liquid through a thin circular outlet, given by

$r = [(3 * rn * \gamma) / (2 * \rho d * g)]$ ^ (1/3), (1) where rn is the outlet radius, ρd is the liquid density, and g is the gravitational constant. The radius can be varied by introducing a force in addition to gravity, which acts to push the liquid out of the nozzle. The droplet transport is modeled using equations of motion while taking all external forces and accelerations under consideration. With the vertical component of the droplet's initial velocity and all vertical forces acting on the droplet, the time required for the droplet to reach the wafer height is calculated. This time is then applied to the horizontal component of the velocity and all horizontal deceleration components acting on the droplet in order to find the horizontal location, where the droplet impacts the wafer surface. When the droplet reaches the vicinity of the wafer, the thermal gradient shown in Fig. 2 begins to affect its motion as well as its physical composition through evaporation. Upon reaching the wafer surface, the droplets which did not fully evaporate proceed to form a tin oxide film. A model for this entire droplet transport sequence, from atomization to deposition, is described in the presented work.

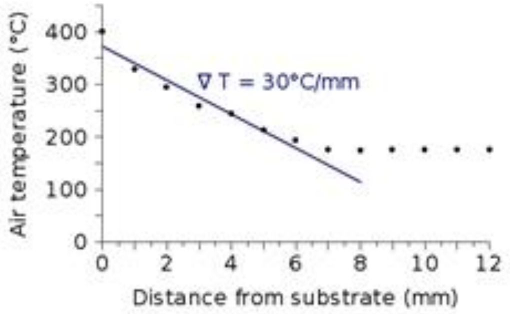

Fig 2. Air temperature above the wafer

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D26: Numerical study of the thermocapillary motion of a droplet in microchannels

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Abstract

Droplet-based microfluidics has attracted significant interest owing to its diverse applications in biotechnology, chemistry, pharmaceuticals and the life sciences. It has many advantages such as high throughput, short analysis time, small volume and high sensitivity. It is essential to manipulate droplets in a precise and flexible manner in droplet-based