Vacuum Science and the Inuence of Vacuum Conditions on Thin Film Growth

Gunther Trk, Jonas Lehnen

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Contents

Abstract

Write here, what we did and learned.

1 Theorie

1.1 Kinetic Gas Theory

In kinetic gas theory we assume a gas to consist of many microscopic spheres which don't interact with each other and take negligible volume in a container.

The particles can move freely and spread homogeneously in a given container. When they crash onto the container walls they exert a force on these, we can measure as pressure.

$$p = F/A$$

It is measured in [Pa] or [bar].

$$[Pa] = N/m^2 \qquad 1bar = 10^5 Pa$$

What we can measure as temperature is caused by the movement of the particles in the gas. So it has to be related to the kinetic energy, what explains why the pressure on the walls rises, if we increase the temperature. From experiments done in the 17th and 18th century we know the state equation for an ideal gas

$$pV = nk_BT$$

where $k_B \approx 1,38J/K$ is the Boltzmann constant and temperature is measured in Kelvin.We assume for our purpose that all particles are incompressible hard spheres and that there are no frictional forces between the particles and the walls. Because the particle speeds are distributed isotropically there are $1/3N$ particles moving along each axis. For simplicity we consider a particle moving along the x-Axis with the velocity v_x. Initially it has the momentum $p_x = v_x{*}m$. After an elastic collision with a wall its momentum is $-p_x$, so the momentum change is $\Delta p_x = 2p_x$. We can calculate the force on the wall by multiplying the momentum change of each collision with the collision frequency. ...

Herleitung von der Kraft auf die Wand

Mittlere Geschwindigkeit

Mittlere freie Weglnge.

1.2 Desorption

1.3 Pumps

We use different pumps to produce a high vacuum for the different pressure regimes. The pre pump is used to get to a low enough pressure to use the turbo pump which gets us to a very high vacuum.

1.3.1 Pre Pump

The pre pump works by changing the volume in a pumping chamber while opening and closing 2 valves.

Hier muss noch ein Bild von einer Pumpe und eine erklrung des arbeitszyklus hin.

The pressure limit we can reach with the pre pump alone is on the one hand caused by leaks of the valves and the piston. On the other hand there is a pressure limit even with perfect pistons and valve by the air at atmospheric pressure which remains in the cylinder at the outlet stage. With adiabatic expansion in the cylinder we can calculate this minimum pressure to be

1.3.2 Turbo Pump

1.4 Sputtering

1.5 Flow

1.5.1 Laminar

1.5.2 Turbulent

1.5.3 Resistance

1.6 Gauges

1.7 Questions

1.7.1 Day1

- What causes the limit on the pressure one can reach with the pre-pump alone?
- Calculate the mean free path of a nitrogen (N2) molecule in atmospheric pressure and at 1 109 mbar
- Based on the data from section 5.3, how much gas is desorped from the walls after the turbo reaches full speed? Hint: Consider the data over the time period after the turbo reaches speed. This is the pressure drop in a xed time. The volume of the chamber is 30 litres and you can assume the chamber is at a constant temperature of 293K. The mass of air is approximately 29g/mol.
- What is the purpose of baking out a chamber?
- What is the thermal energy at room temperature and the corresponding thermal speed of a water molecule (H2O)?

1.7.2 Day2

- Can you name some properties which might arise due to scaling down the thickness of a sample?
- How have the elemental peaks changed from the spectra of the rst day? What can you say about the baking process? How will the baking process aect the quality of the samples being grown?
- Why does the pressure oscillate with clear periods of increasing and decreasing pressures during baking?
- What happens to the plasma as you increase the power being applied to the cathode? Page 14 of 34
- Why do we pre-sputter the target before deposition?
- Plot the Polanyi-Wigner equation as a function of desorption energy for an ensemble of 5.35x1013 particles for Tw = 300K, 500K, 800K, 1000K for Edes between 0 and 60 kJ/mol-1 (universal gas constant 8.31 J/mol-1). Scale the y-axis to 1013 as a maximum.

2 Experiment

2.1 Description

2.2 Data Analysis

2.3 Evaluation