About a strong line shift effect in glow discharges

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Abstract

Glow discharge spectra of some oxide materials show a noticeable blue shift of the oxygen lines. The further investigation presented here, point to the fact that lines of other dielectrically different materials also receive a similar blue shift. Hence, an explanation would be, that those elements represent carriers of the electric charge and last not as negative ions when sputtered. Then, in the cathode fall region, an acceleration would take place in the direction of the optical detector and correspondent Doppler shift to smaller wavelengths would be the result. The observed blue shift is substantially larger than we could expect from the larger charge carriers, it suggests the formation of a free electron gas. The line shift is shown in the sequence of blue shifts in glow discharges.

Experimental

In the experiments presented here, a source according to Grimm was used. The characteristic of such a plasma source is also described in detail in the literature on the topic. The spectrometer used is a conventional Analytische Röntgenstrahlengenie (AROS 102) x-ray diffraction and additional DRX900 monochromator. The monochromator was used here for the recording of the Balmer alpha line. The spectral resolution of the monochromator is 20 pm. The scans were performed at 1 pm spectral resolution (1 pm monochromator).

Influences of material and plasma gas

For the trace level of oxygen in the gas and not of conductive, inert cathode materials show such line shifts as found. The best thus far yielding the effect was a non-conductive fast sputtering oxide-like material (strontium ferrite). Conductive materials show only a relatively small effect and beams of air and nitrogen shows there is absolutely no difference in the results. The spectrum, which was used here in the conductive sample was 99.99% perfect conductor but includes fractions of silicates and phosphates. An extremal gain of the effect only appears with the association of non-conductive oxide. In my experiments this was the only way to produce a small effect also with a non-conductive oxide (Fig. 2).

Common Doppler effects in glow discharge plasmas

A well-known Doppler effect in glow discharge in the broadening of Balmer alpha line. This is a blue and red shift both sputter gases explicitly look similar, and have only negligibly little to do with the variation of material or plasma conditions. The intensity of both kinds of hydrogen lines remains only so weak that it can only be detected with high-resolution spectrometers. The amount of both shifts can be explained with the formal constraint rates [5] (a) (d) of (e) of the wings (Fig. 4). For some additional measurement the Doppler effect is also noticed to have about these influences on the measurement and to be able to make corrections.

On the other hand, the effect opens a new look on some interesting, new and acceptable trends and phenomena. First of all, all the investigations of oxygen surrounding the analysis of non-conductors by glow discharge sputtering. A new field for detection of certain material properties, such as the nature of the oxide bonds, electrical properties, especially in thin layers, seems to be justified. Another would be an application for the effect with depth profiling analyses of thin conductive layers, single or multi- layers, or even on bulk materials. Some measurable material-specific parameters of the effect, like the amplitude ratio and the threshold voltage, should be useful for a correlation with certain electrical, mechanical or geometric properties.

Prospects

A possible idea of a new metal cathode. It was just for the last five years that noticeable works to negative ions in plasmas have been published [20]. The author of this paper was responsible for this idea.

References

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Fig. 1: Fundamental characteristics of the strong line shift effect in the example of strontium ferrite as cathode and argon + 2% hydrogen as plasma gas. A) With increasing voltage the intensity minimum shifts slightly towards shorter wavelengths, while the complete peak stays within the Doppler effect limit 2 [radianic curve]. B) The ratio of the amplitudes of the blue peak and the initial spectral line depends on pressure and voltage. It changes reciprocally proportional to the pressure. The effect occurs above a limiting voltage Uc. C) A reproase increase leads to a reverence peak. The Doppler effect limit as the predictable extreme of the shift is only reached at the lowest pressures. The spectral intensity distribution was described using the Wulff statistic [8]. Exteme ranges 500 V or 1500 V (p = 0.05 Pa) are indicated by extrapolation.