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Technology Offer

Method for quantitative analysis of electrostatic charging of a specimen

Ref.-No.: 0601-6026-BC

"Electrostatic charging of electrically insulating samples upon electron (or other ionizing) irradiation plays an important role in the analysis and processing of samples in the semiconductor industry. Quantitative analysis of electron beam-induced electrostatic fields in specimen remains extremely difficult. This invention solves this problem by using an insulating electrochromic material, which allows to analyze electron beam-induced electrostatic fields temporally and spatially via optical spectroscopy."

Background

Electrostatic charging of electrically insulating samples upon electron (or other ionizing) irradiation plays an important role in the analysis and processing of samples in the semiconductor industry. Examples include electron beam lithography and the inspection of wafers and photomasks with electron beams.

Two processes are responsible for the electrostatic charging of insulating specimens upon electron irradiation: emission of secondary electrons from the surface and implantation of electrons in the bulk. Electrostatic charging causes deflection of the electron beam, which reduces the accuracy of electron beam lithography and imaging. Quantitative analysis of time-dependent electrostatic fields in the specimen remains extremely difficult.

This invention solves this problem by using an insulating electrochromic material, which allows to analyze electron beam-induced electrostatic fields temporally and spatially via optical spectroscopy.

Technology

Insulating electrochromic materials show color changes upon irradiation with an ionizing beam (electron beam). Figure 1 demonstrates schematically the electron beam-induced spectral changes in an electrochromic material. Irradiation with an electron beam triggers the emission of secondary electrons (SE, Fig. 1A) and is accompanied by the implantation of electrons (Fig. 1 B). This leads to electrostatic charging of the electrochromic material and therefore to a color change. After a certain time, due to thermal recombination, the color change fades out (Fig. 1 C).

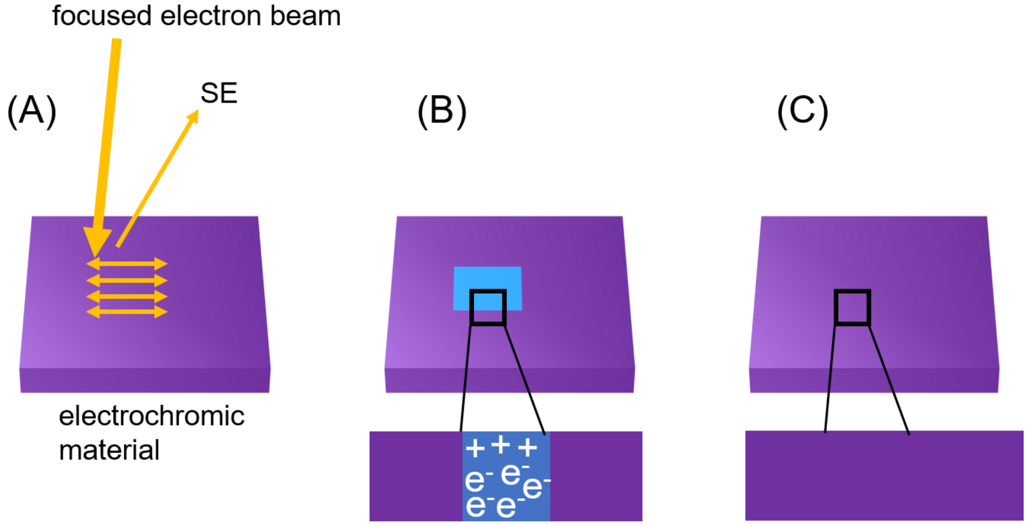

Figure 1. Schematical sketch of an electrochromic material upon irradiation with an electron beam. See text for further explanations. *(Source: Figures (slightly modified) from Rhinow & Hampp (2020, https://aip.scitation.org/doi/full/10.1063/5.0022695))*

Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de

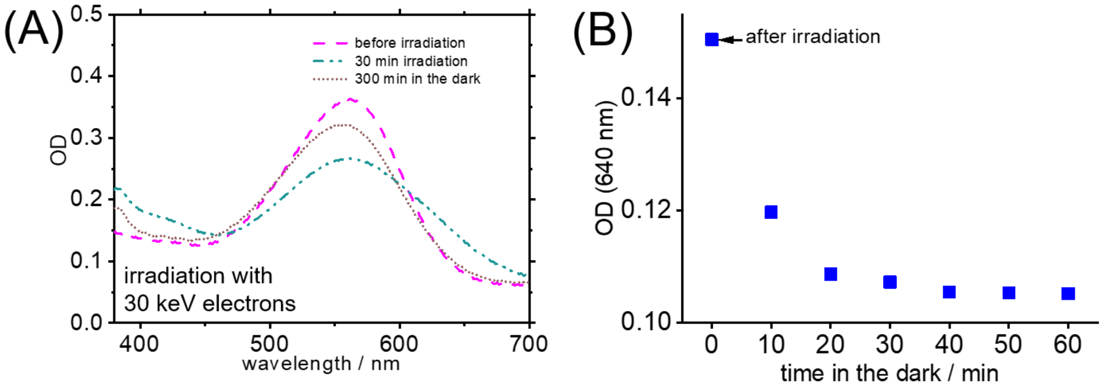

Figure 2. Time-dependent UV/VIS spectroscopy of an electrochromic film (biological material bacteriorhodopsin used for a demonstration embodiment) after electron irradiation. Optical spectroscopy reveals reversible formation of a bathochromic species upon electron irradiation, a measure for the visible color change of the demonstrator. (A) Electron irradiation for 30 min, corresponding to an electron dose of 10.8 μC/cm^2, leads to the formation of a bathochromic species. (B) Time-dependent UV/VIS spectra for a film that had been irradiated with electrons for 30 min. The film then has been transferred into an UV/VIS spectrometer (into the dark), and after (further) 30 min, the electron irradiation-induced bathochromic state has disappeared. *(Source: Figures (slightly modified) from Rhinow & Hampp (2020, https://aip.scitation.org/doi/full/10.1063/5.0022695))*

Future technological applications focus on synthetic electrochromic dyes and allow, e.g.,

1. Temporal and spatial analysis of the electrostatic charge in a specimen upon irradiation with an electron (or another ionizing) beam. The analysis is done by optical spectroscopy of the electrochromic material. New insights into charging processes in photoresists, wafers and photomasks will be gained.
2. Coating or doping of insulating materials, used in the semiconductor industry, with electrochromic materials, to investigate electron beam-induced charging directly in relevant materials, e.g., quartz or photoresists.

Further applications related to our IP are also conceivable:

3. Spectral changes in electrochromic dyes, caused by electron irradiation, could be used for the production of opto-electric devices.
4. Usage of electrochromic devices as sensors to analyze electron beams quantitatively. In this context, the reversibility of the spectral changes is of great importance.
5. The applications also hold for other ionizing radiation, e.g., extreme ultraviolet (EUV) light.

More information

Available under: https://aip.scitation.org/doi/full/10.1063/5.0022695

Advantages of the invention

- Allows easy real time measurements of electrostatic charge in a material upon exposure to an electron beam or another kind of ionizing radiation.
- Provides quantitative analysis of electrostatic charging in photoresists, wafers and photomasks upon electron irradiation and allows therefore an optimization of the technical processes.
- Allows to build new opto-electronic devices and sensors.

Patent Information

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Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de

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Contact

Dr Bernd Ctortecka
Senior Patent- & License Manager
Physicist
Phone: +49 (0)89 / 29 09 19 - 20
eMail: ctortecka@max-planck-innovation.de