From Characterization to Application: Modelling 2D material-based conductive de-icing layers

Markus Ostermann[1], Pierluigi Bilotto[1], Jürgen Schodl[1], Peter Lieberzeit[2], Markus Valtiner[1,3]

[1] *CEST GmbH, Centre for Electrochemical Surface Technology, A-2700, Wiener Neustadt, Austria*
[2] *Institute of Physical Chemistry, University of Vienna, A-1090, Vienna, Austria*
[3] *Applied Interface Physics, TU Wien, A-1040, Vienna, Austria*

markus.ostermann@cest.at

Climate change requires to improve efficiency of aircraft to ensure sustainable operation within the next years. Composite materials substituting alumina structures decrease the overall weight and simultaneously the fuel consumption significantly, but prevent the use of bleed air systems for de-icing of structural parts. 2D-material based thermoelectrical systems are a lightweight alternative for de-icing.

Electrochemically produced graphene nanosheets are applied on aeronautical substrates via spray-coating. The resulting conductive layer (see Fig. 1 a)) appears in suitable resistance ranges for thermoelectrical de-icing. Simple characterization methods (e.g., XRD, powder conductivity and roughness measurement) elucidated parameters like crystallite sizes, particle conductivity and substrate roughness. In combination with Monte-Carlo simulation modelling the contact area of individual particles, a mathematical description of the particle layer's conductive properties was established (see Fig. 1 b)). This model enables us the prediction of conductive properties based on the amount of 2D material sprayed on various substrates and further produce tailored properties to the respective heating demands of an aircraft operating in icing conditions. [1,2]

Due to the simplicity of the model parameters, transfer to other 2D materials and a broad variety of substrates is possible. By understanding the electrical properties of 2D materials based functional layers, the applicability of the model extends also to fields like electrocatalysis, energy materials and sensors.

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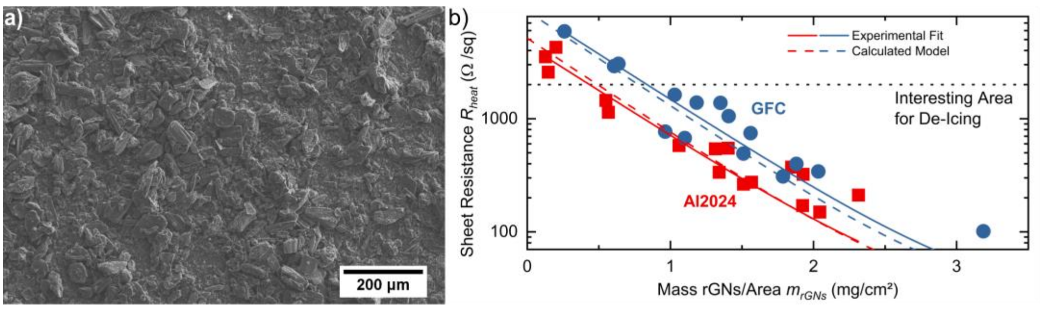

Fig. 1. a) Graphene Nanosheets (GNs) sprayed on an epoxy-coated Al2024 substrate; b) Relation between sheet resistance and applied GNs concentration on two substrates: experimental fit and established math. model. [2]

[1] Ostermann M, Velicsanyi P, *et al.* Development and Up-Scaling of Electrochemical Production and Mild Thermal Reduction of Graphene Oxide. Materials. 2022; **15(13)**:4639. DOI: 10.3390/ma15134639
[2] Ostermann M, *et al.* L-Ascorbic Acid treatment of Electrochemical Graphene Nanosheets: Reduction Optimisation and Application for De-Icing, Water Uptake Prevention and Corrosion Resistance. ACS Applied Materials & Interfaces; 2023, **15 (18)**, 22471-22484. DOI:10.1021/acsami.2c22854