Simulation-Enhanced Measurement of Thermal Conductivity Coefficient in Polyurethane with Admixtures

Marian Janek[1, a)], Stefan Hardon[1], Jozef Kudelcik[1], Ondrej Michal,[2] and Miroslav Gutten[3]

[1]*Department of Physics, Faculty of Electrical Engineering and Information Technology, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic*
[2]*Department of Materials and Technology, Faculty of Electrical Engineering, University of West Bohemia, 306 14 Pilsen, Czech Republic*
[3]*Department of Mechatronics and Electronics, Faculty of Electrical Engineering and Information Technology, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic*

[a)] *Corresponding author: janek5@uniza.sk*

Abstract. Predicting the effective thermal conductivity of polyurethane (PU) composites with admixtures like Aluminum Nitride (AlN) is crucial for optimizing materials for thermal management. This study compares experimental measurements of thermal conductivity in PU (VUKOL Magna Blue) -AlN composites (up to 50 wt% AlN) with predictions from several established theoretical models: Maxwell-Eucken (standard and with Thermal Boundary Resistance - TBR), Lewis-Nielsen, Agari, Bruggeman, and Agrawal. Experimental results show a steady increase in effective thermal conductivity from 0.2 W/mK (pure PU) to approximately 0.65 W/mK (50% AlN). Comparison reveals varying degrees of agreement between models and data. The Lewis-Nielsen and Agari models show closer alignment with the experimental trend, particularly at lower to intermediate filler concentrations, while the Bruggeman model significantly overestimates, and the Agrawal model underestimates effective thermal conductivity across most of the range. This work highlights the importance of selecting appropriate theoretical models and considering factors like TBR and filler characteristics when predicting the thermal behavior of PU composites.