Novel Interferometric Detection of Nitrate and Phosphate Runoff to Protect Marine Ecosystems and Rural Water Supplies

Sulek, Jagoda (School: II Liceum Ogolnoksztalcace z Oddzialami Dwujezycznymi im. Stefana Batorego)

The lack of control over nitrate and phosphate levels in soil and water is becoming one of the most serious problems facing the Baltic Sea. Eutrophication and uncontrolled nutrient runoff lead to the formation of "dead zones," which currently cover approximately 20% of the sea's surface area. Furthermore, these contaminants pose significant health risks, such as methemoglobinemia, and economic challenges for small-scale agriculture. While laboratory detection methods exist, they often require long and intensive sample preparation. Effective in situ monitoring is currently prevented by a fundamental physical barrier: strong water absorption of infrared radiation, which in standard FTIR spectroscopy saturates the detector and masks chemicals' signal. To make a step forward into direct real-time detection, innovative optical filters for FTIR were developed. The goal was to block the wavelengths characteristic of water absorption bands selectively. Multilayer dielectric alternating nanostructures (TiO2/SiO2) were designed and fabricated by PVD on germanium (Ge) substrates, to quench the water absorption bands (3300 cm?¹ and 1640 cm?¹). Optical background removal prevents sensor saturation, which may enable in situ detection, even at lower concentrations, by significantly improving the signal-to-noise ratio. The filters were subjected to laboratory tests - reflectance measurements. The experimentally obtained spectra demonstrated high agreement with the results of computational Python-based models. The project represents the first application of optical filters for the detection of chemical contaminants in the environment, paving the way for the democratisation of environmental monitoring and the protection of water resources.

Awards Won:
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: Full Scholarship from King Fahd University of Petroleum and Minerals(KFUPM) (and a $400 cash prize)
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: NOT TO BE READ -- $400 cash prize for each Full Scholarship from King Fahd University award recipient