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Development of X-ray emission spectroscopy analyzer with low voltage SEM and STJ array X-ray detector for nanometer-scale chemical state imaging

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Carbon fiber reinforced plastics (CFRPs) exhibit a high strength-to-weight ratio and a toughness better than those of metals. Because of such superior mechanical properties, CFRP-composite materials are becoming popular in aircraft and automobile industries. The lightweight structure brings many benefits like a good fuel efficient, which is the central issue in transportation. CFRP composites have many interfaces such as adhesion and fiber-resin boundaries, which affects mechanical properties and reliability. It is important to analyze chemical bonding states at those boundaries. However, chemical bonding state analysis at the boundaries has not been realized so far, since analysis at a spatial resolution of less than 10 nm should be performed without irradiation damage of molecules.

In order to realize the analysis, we have developed an X-ray emission spectroscopy analyzer combining a low acceleration voltage SEM (LVSEM) and a 100-pixel superconducting tunnel junction (STJ) array X-ray detector. LVSEMs enable acquisition of material information at a nanometer spatial resolution because of a short electron. The STJ array installed in the LVSEM realizes a high-throughput X-ray emission spectroscopy, since it has an energy resolution much better than natural line widths of characteristic X-rays of light elements. We analyzed CFRP samples to check the analyzer performance, it was possible to differentiate carbon atoms either in fibers and matrix resin by observing C-$K\alpha$ emission line shapes. Since X-ray emission line shapes represent the density of the states of valence electrons and probably molecular orbits like σ^* and π^*, it may be possible to image chemical bonding state at a nm scale resolution.

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Less than 5 years of experience since completion of Ph.D

N

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N

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