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論　文　内　容　要　旨

報告番号	甲　先　第　354　号	氏　名	YATIN MADHUKAR BHAMARE
学位論文題目	Ultrafast Carrier Dynamics of Laser-ablated Graphite and Reduced Graphene Oxide with Metal Composites (レーザーアブレーション処理したグラファイトおよび金属複合化した還元型酸化グラフェンにおける超高速キャリアダイナミクス)		

内容要旨

Carbon based materials are considered as a rewarding contestant for optical devices due to its novel properties. Graphite is a most stable allotrope of carbon with a layered and planar structure. Graphene is the two-dimensional lattice of carbon atoms in a honeycomb arrangement, and is attracting significant attention from the scientific community. There was a rapid growth of graphene-based two-dimensional counterparts, the most famous among which is reduced graphene oxide (rGO). Carbon-based semiconductors like graphene are suitable candidates for photocatalytic degradation. Incorporation of metal nanoparticle in reduce graphene oxide, such as Au, Pd and Pt are capable of absorbing visible light. The photocatalytic performance of rGO-Au, rGO-Pd and rGO-Pt photocatalyts is investigated by the degradation of Methylene Blue (MB) under UV and visible light. Ultrafast spectroscopy is a powerful experimental technique for studying photo-generated carrier dynamics while controlling the physical parameters such as the size of nanoparticle (NP). In this study, ultrafast carrier dynamics of graphite, laser-ablated graphite and reduced graphene oxide is investigated, aiming future application of optical switching. Ultrafast carrier dynamics of rGO-Au, rGO-Pd and rGO-Pt is investigated aiming the application of photocatalysis.

In this study, graphite is laser-ablated and different analytical methods such as XRD and Raman spectroscopy are used to evaluate the crystalline nature. Reduced graphene oxide is prepared by using modified Hummers method and reduced it by thermal reduction method. It is decorated with Au, Pd and Pt nanoparticles by chemical synthesis. In XRD, it indicates the decreased intensity after laser ablation but no change in peak positions resulted as graphite is very strong and hard material. Raman spectroscopy indicates, after laser ablation, D-band and G′-band peaks are slightly shifted to larger wave number side by 5-10 wave numbers, but there is no obvious change in peak position for G-band. Also, the G/D ratio decreases from 4.13 to 3.38, indicating the edge effect in laser ablated nanostructures. Ultra-violet visible spectra confirmed the peaks of both graphite (non-ablated and laser-ablated) and rGO at 274 nm and 267 nm, respectively. It also confirms the synthesis of rGO with Au, Pd and Pt composites successfully. Scanning electron microscopy (SEM) used to evaluate structural characteristics shows the overlapping layered structure after ablation. It also reveals the layered structure of rGO with successful composition of Au, Pd and Pt nanoparticles. Photocatalysis activity of rGO with Au, Pd and Pt was observed using UV-Vis spectroscopy. rGO-Au shows faster degradation of methylene blue using both xenon white lamp and blue LED.

To study the ultrafast carrier dynamics, femtosecond transient absorption spectroscopy was used. Graphite, laser-ablated graphite and rGO shows carrier relaxation between 260 fs and 309 fs even after laser ablation damage. rGO shows transient absorption intensity about 6.7%, while both graphite samples showed 3.5%, which is useful for future application of optical switching under high laser repetition. Photocatalysis activity shows faster degradation of methylene blue for rGO-Au composite in 90 minutes using both xenon white lamp and blue LED. rGO-Pd composite takes 120 minute, and also rGO-Pt composite takes 120 minute for degradation of methylene blue using xenon white lamp. Also, using blue LED both rGO-Pd composite and rGO-Pt composite shows slower degradation rate than rGO-Au composite. rGO-Au composite is useful composition for the photocatalysis activity. rGO with Au, Pd and Pt shows carrier relaxation between 177 fs and 304 fs with long lived component in ultrafast carrier dynamics. The faster degradation tendency in rGO-Au composite was seen because Au nanoparticle shows surface plasmon resonance absorption in visible region about 520 nm wavelength and inter-band excitation in ultra-violet region about 400 nm wavelength. Surface plasmon resonance absorption and inter-band excitation of Au nanoparticle shows rGO-Au is useful composition for photocatalysis activity.