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## Electrically controllable spin states in single-layer graphene: Direct observation by ESR spectroscopy

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Graphene has been actively investigated as an electronic material owing to many excellent physical properties such as high charge mobility and quantum Hall effect due to the characteristics of a linear band structure and an ideal two-dimensional electron system. However, the correlations between the transport characteristics and the spin states of charge carriers or atomic vacancies in graphene have not yet been fully elucidated. Here, we show the spin states of single-layer graphene to clarify the correlations using an electron spin resonance (ESR) spectroscopy as a function of accumulated charge density using transistor structures. Two different electrically induced ESR signals were observed. One is originated from a Fermi-degenerate two-dimensional electron system, demonstrating the first observation of electrically induced Pauli paramagnetism from a microscopic viewpoint, showing a clear contrast to no ESR observation of Pauli paramagnetism in carbon nanotubes (CNTs) due to a one-dimensional electron system. The other is originated from the electrically induced ambipolar spin vanishments due to atomic vacancies in graphene, showing a universal phenomenon for carbon materials including CNTs. The degenerate electron system with the ambipolar spin vanishments would contribute to high charge mobility due to the decrease in spin scatterings in graphene.

### Biography

Kazuhiro Marumoto has completed his PhD from Osaka University and worked as an Assistant Professor at Nagoya University. He is an Associate Professor of Division of Materials Science at University of Tsukuba and also a Member of Tsukuba Research Center for Interdisciplinary Materials Science (TIMS) at University of Tsukuba. He has published more than 140 papers in journals and has been serving as a Chief Editor of The Society of Electron Spin Science and Technology (SEST) and an Editorial Board Member of *Scientific Reports*.

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