Research team develops the first flexible phase-change random access memory

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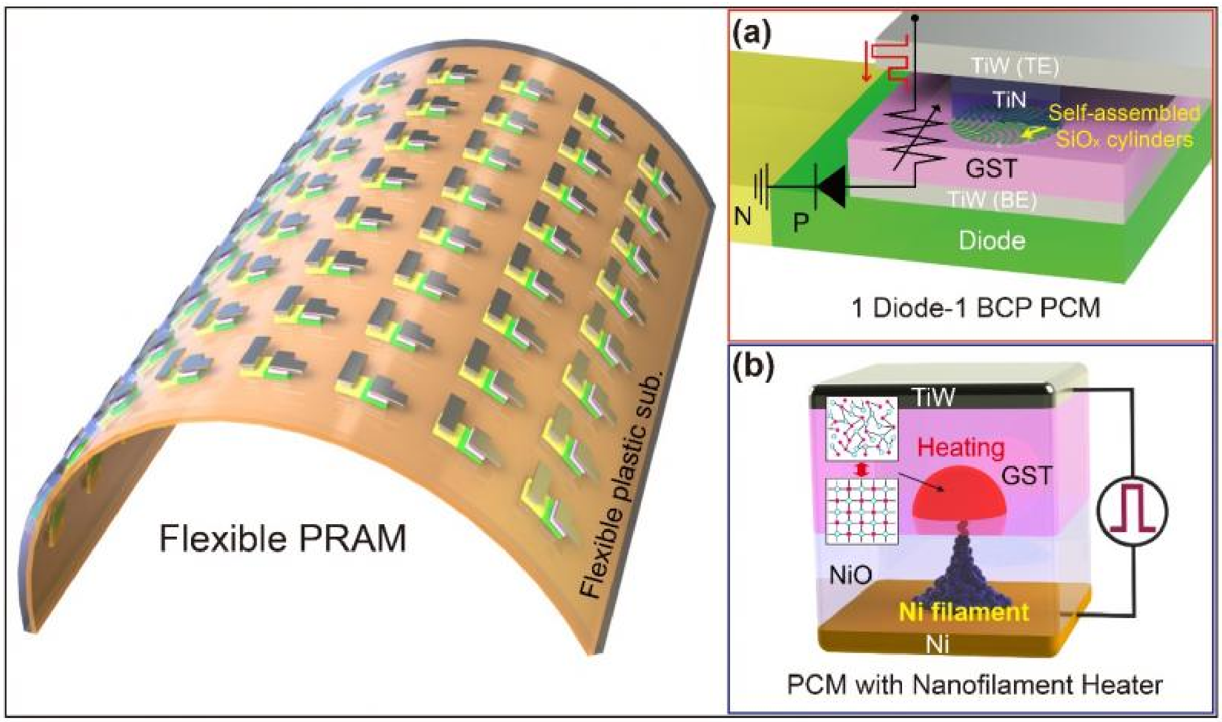

Low-power nonvolatile PRAM for flexible and wearable memories enabled by (a) self-assembled BCP silica nanostructures and (b) self-structured conductive filament nanoheater. Credit: KAIST

Phase change random access memory (PRAM) is one of the strongest candidates for next-generation nonvolatile memory for flexible and wearable electronics. In order to be used as a core memory for flexible devices, the most important issue is reducing high operating current. The effective solution is to decrease cell size in sub-micron region as in commercialized conventional PRAM. However, the scaling to nano-dimension on flexible substrates is extremely difficult due to soft nature and photolithographic limits on plastics, thus practical flexible PRAM has not been realized yet.

Recently, a team led by Professors Keon Jae Lee and Yeon Sik Jung of the Department of Materials Science and Engineering at KAIST has developed the first flexible PRAM enabled by self-assembled block copolymer (BCP) silica nanostructures with an ultralow current operation (below one quarter of conventional PRAM without BCP) on plastic substrates. BCP is the mixture of two different polymer materials , which can easily create self-ordered arrays of sub-20 nm features through simple spin-coating and plasma treatments. BCP silica nanostructures successfully lowered the contact area by localizing the volume change of phase-change materials and thus resulted in significant power reduction. Furthermore, the ultrathin silicon-based diodes were integrated with phase-change memories (PCM) to suppress the inter-cell interference, which demonstrated random access capability for flexible and wearable electronics. Their work was published in the March issue of *ACS Nano*: "Flexible One Diode-One Phase Change Memory Array Enabled by Block Copolymer Self-Assembly."

Another way to achieve ultralow-powered PRAM is to utilize self-structured conductive filaments (CF) instead of the resistor-type conventional heater. The self-structured CF nanoheater originated from unipolar memristor can generate strong heat toward phase-change materials due to high current density through the nanofilament. This ground-breaking methodology shows that sub-10 nm filament heater, without using expensive and non-compatible nanolithography, achieved nanoscale switching volume of phase change materials, resulted in the PCM writing current of below 20 uA, the lowest value among top-down

PCM devices. This achievement was published in the June online issue of *ACS Nano* "Self-Structured Conductive Filament Nanoheater for Chalcogenide Phase Transition." In addition, due to self-structured low-power technology compatible to plastics, the research team has recently succeeded in fabricating a flexible PRAM on wearable substrates.

Professor Lee said, "The demonstration of low power PRAM on plastics is one of the most important issues for next-generation wearable and flexible non-volatile memory. Our innovative and simple methodology represents the strong potential for commercializing flexible PRAM."

In addition, he wrote a review paper regarding the nanotechnology-based electronic devices in the June online issue of *Advanced Materials* entitled "Performance Enhancement of Electronic and Energy Devices via Block Copolymer Self-Assembly."

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