Numerical simulation of nano-magnet counter driven by strain

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With MQCA (magnetic quantum dots cellular automata), also called NML (nano-magnetic logic), we can design binary logic gates by changing the shapes and positions of nano-magnetic dots. An external magnetic field is often used to trigger these logic gates [1]. Recently, a strain induced by a piezo element is also used as a trigger. These devices are called straintronics devices, which gather attention to achieve low energy consumption devices [2]. The strain can be applied not only by fabricating nanomagnets on the piezo element but also fabricated on a flexible substrate[3]. With these flexible substrates, one can apply a trigger signal with a force that appears in our living space (e.g. a force by our finger). Therefore, an MQCA with flexible substrates can be used as an interface between our physical behaviour and cyberspace. In this study, we design and simulate behaviours of a nano-magnetic counter that can be triggered with strain.

Figure 1 shows a schematic illustration of nano-magnet counter which composed of fixed dot, buffer dots and data dots. The fixed dot has a high aspect ratio which provides a high switching energy barrier. Fig. 2 shows the typical simulation results after applying the trigger strain. At the initial state, only the magnetisation of the fixed dot points $+x$ direction. On the other hand, the x-component of the magnetisations of the other dots are negative. A strain, which is used for a trigger, is applied to the entire dots with an angle of 45° from the x-axis. After the trigger was applied, the magnetisation of the buffer dots and data dots are reverted from the left-hand side with a change of the anisotropy of the nanomagnet. By measuring the magnetisation state, we can determine the count of the strain applied to the nanomagnets. Therefore, this element can be used as a counter. By creating straintronics devices on a flexible substrate, we can update the state of the device without using an electrical signal but using a motion of our body.

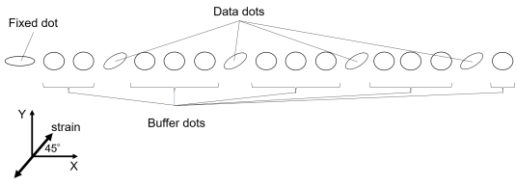

Fig. 1 Schematic illustration of nano-magnet counter. condition of the counter.

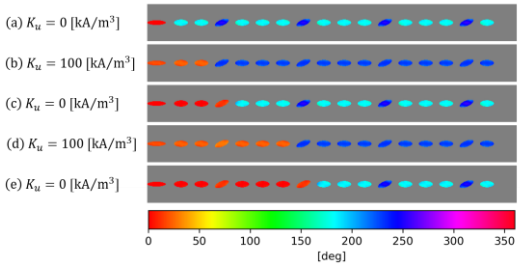

Fig. 2 Typical simulation results of the nanomagnet counter.

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