Non-exponential resistive switching in Ag_2S memristors: a key to nanometer-scale non-volatile memory devices

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Abstract

Future technological developments in non-volatile resistance switching random access memory (ReRAM) applications [1] exceeding the limitations of present-day flash devices are expected to comply with the basic requirements of a small size for a high data storage density as well as fast read and write operations performed at reasonably low voltages and easily detectable current levels. Moreover, it is also a key issue that such passive circuit elements exhibit a strongly non-linear response function, so that the device is stable against low-level read-out signals and, at the same time, responds quickly to write operations carried out at higher biases. Tunable, nanometer scale junctions formed between metallic electrodes by reversible solid state electrochemical reactions represent extremely promising candidates to satisfy the above criteria [2]. The resistive state of such a memory element, called memristor [3] is altered by biasing the device above its writing threshold (V_{th}). Readout is performed at lower signal levels which preserve the stored information.

We studied the dynamics of the resistive switchings in Ag–Ag_2S–PtIr nanojunctions [4]. We showed that the resistance change simultaneously exhibits multiple time scales ranging from a nanosecond to seconds upon a switching voltage pulse. The resulting non-exponential transition between the OFF and ON states as well as the achievable, technologically convenient R_{OFF}/R_{ON} = 2–10 ratios are largely affected by the amplitude and frequency of the biasing signals. This fundamental, inherent property of the Ag_2S ionic conductor provides the unique opportunity for combination of GHz write/erase operations [5] performed at bias levels of a few Volts, non-volatile read-out with slower signals of a few 10 mV and robust information storage at zero bias in a two-terminal, nanometer scale analog memory device.

References

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Figures

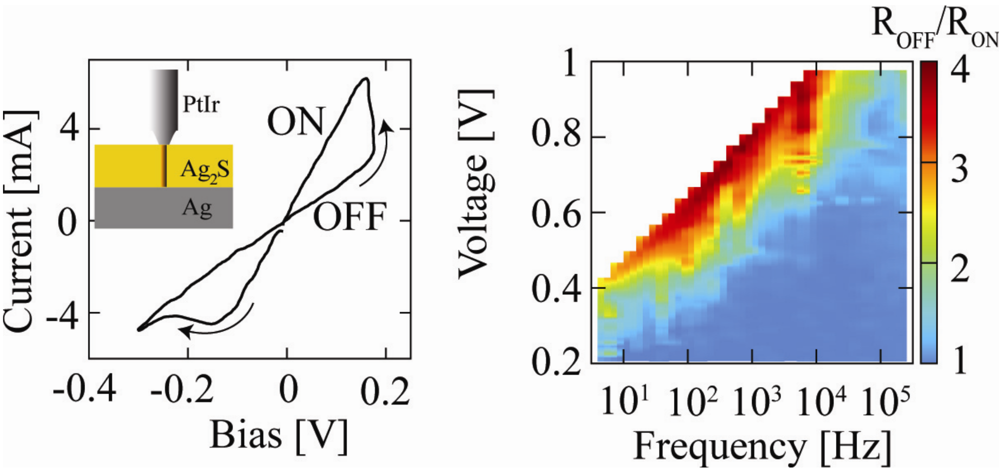

Fig.1 Resistance ratio R_{OFF}/R_{ON} as a function of the driving frequency and amplitude as deduced from the hysteretic I-V traces recorded in PtIr-Ag_2S-Ag nanojunctions established in an STM setup.