Triphenylamine-Substituted Polymer-Active Resistive Memory Devices with Different Memory Types

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Introduction

In comparison to memory devices based on inorganic materials, polymeric memories exhibit advantages of low-cost potential, simplicity in structure, good scalability, 3D stacking capability, large capacity for data storage, and flexibility.1 A number of organic materials, including conjugated molecules and polymers,2,3,4 dopant,5 and complex systems,6 have been investigated for memory applications.

Results and Discussion

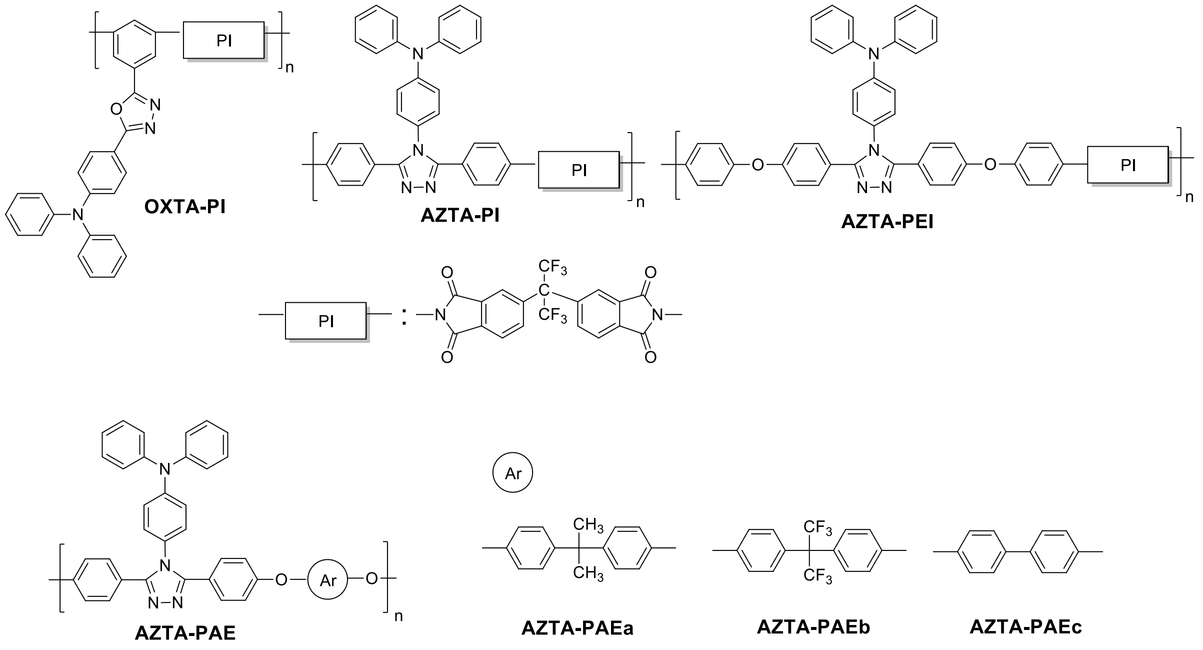
Two series of polymer-based memory materials including polyimides and poly(aryl ether)s are sketched in [Scheme 1]. The three polyimides (OXTA-PI, AZTA-PI, AZTA-PEI) were prepared by a conventional two-step method. The glass transition temperatures of the three polyimides are 317, 304 and 273 °C, respectively. The poly(aryl ether)s (AZTA-PAE series) were prepared from the newly prepared difluride (3,5-bis(4'-fluorophenyl)-4-nitrophenylamine-1,2,4-triazole)) and analogue bisphenols via nucleophilic aromatic substitution reactions. The glass transition temperatures of the three poly(aryl ether)s are 187, 201 and 199 °C, respectively, for AZTA-PAEa, AZTA-PAEb and AZTA-PAEc. The polymers (AZTA-PEI and AZTA-PAE series) containing ether moiety showed better solubility and lower glass transition temperatures than the rigid polyimides (OXTA-PI and AZTA-PI) due to the flexible linkage.

The memory effects of the polymers are summarized in [Table 1]. The memory devices based on AZTA-PAE polymers showed similar switching behavior.. The polymers only can be switched on (write in) in negative sweep and switched off (erasing) in positive sweep.

On the other hand, the polyimide series exhibited very different memory effects from poly(aryl ether) series. The polyimides exhibited similar memory effects with different switching behaviors as summarized in [Table 1]. Taking as an example, the memory effects of ITO/AZTA-PI/Al device are shown in [Figure 1]. The non-volatile and non-rewritable natures of the ON state demonstrate that the AZTA-PI based device exhibits write-once read-many-times (WORM) type memory effects.

Conclusions

The memory effects of poly(aryl ether)s containing 1,2,4-triazole in the main chain and pendant triphenylamine moieties exhibit flash memory effect, while polyimides containing oxadiazole or 1,2,4-triazole moiety in the main chain with pendant triphenylamine groups showed WORM characteristics. The polymer AZTA-PEI containing imide and ether groups showed WORM effects. The imide plays an important in the memory effects.



Scheme 1. Polymer structures for the polymer memory application

Table 1. Memory properties of polymers containing donor and acceptor moieties

Polymers	**Poly(aryl ether)s**			**Polyimides**		
Polymer code	**AZTA-PAEa**	**AZTA-PAEb**	**AZTA-PAEc**	**OXTA-PI**	**AZTA-PI**	**AZTA-PEI**
Memory type	Flash	Flash	flash	WORM	WORM	WORM
Writing voltage [V]	–6.3	–1.5	–1.8	±1.8	±2.5	±3.0
Erasing voltage [V]	1.1	2.0	0.6	–	–	–

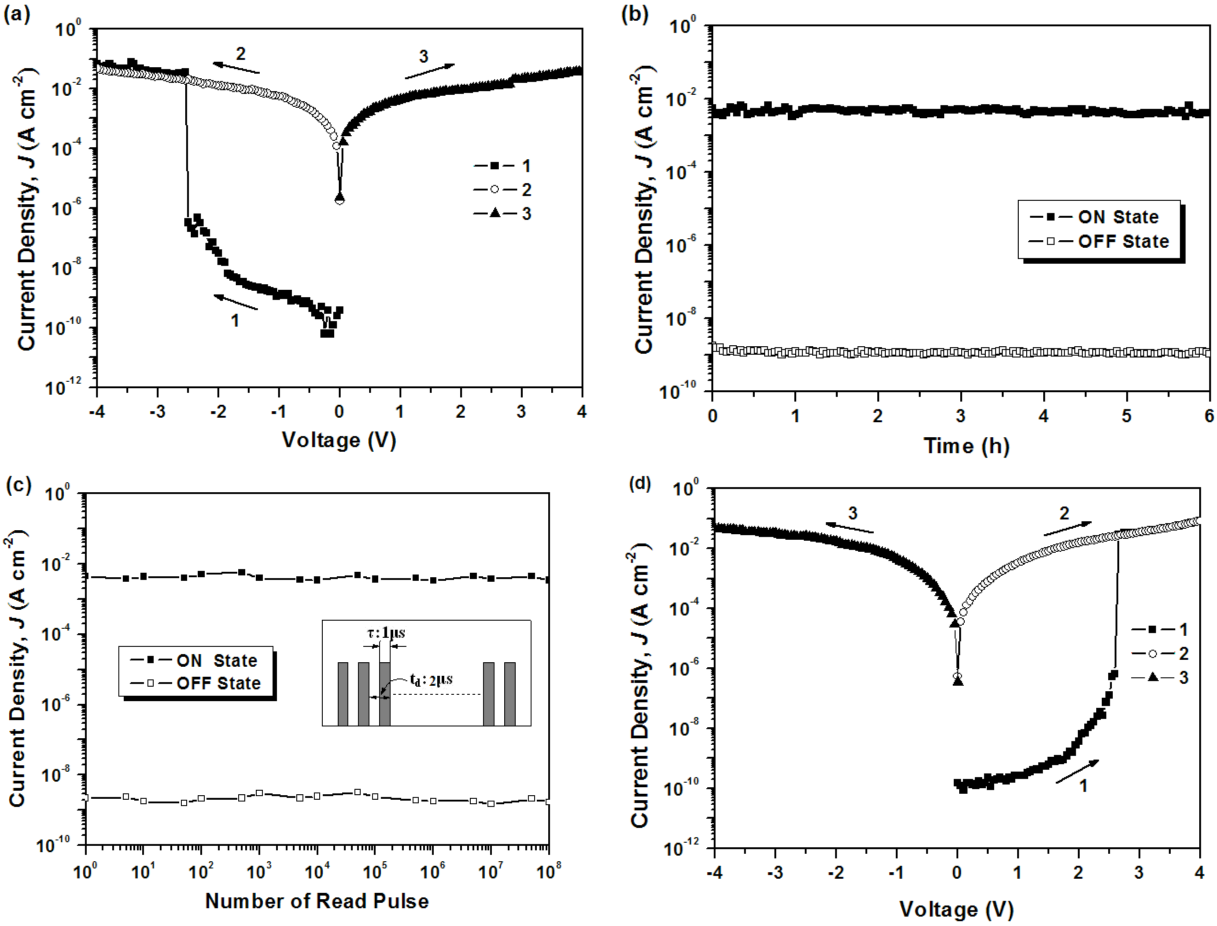


Figure 1. (a) J-V characteristics of ITO/AZTA-PI/Al device with an initial negative electrical sweep (b) Effect of operation time on the ON and OFF states of the memory devices under a constant stress of -1 V at room temperature.

References

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