Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supporting Information

Charge Trapped CdS Quantum Dots Embedded Polymer Matrix for High Speed and Low Power Memristor

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Schematic of Synthesis and fabricated device:

The schematic of CdS quantum dots (QDs) synthesis using the hot injection reaction method (S1 (a)-(c)). Cd precursor was prepared under an N_2 environment and S precursor was injected at 200˚C. The prepared CdS QDs taken into a test tube and ethanol and acetone mixture were added to clean the QDs. The solution was centrifused for 5 minutes at 4000 rpm a yellow precipitate can be found. The precipitate was redisperse in toluene for further use.

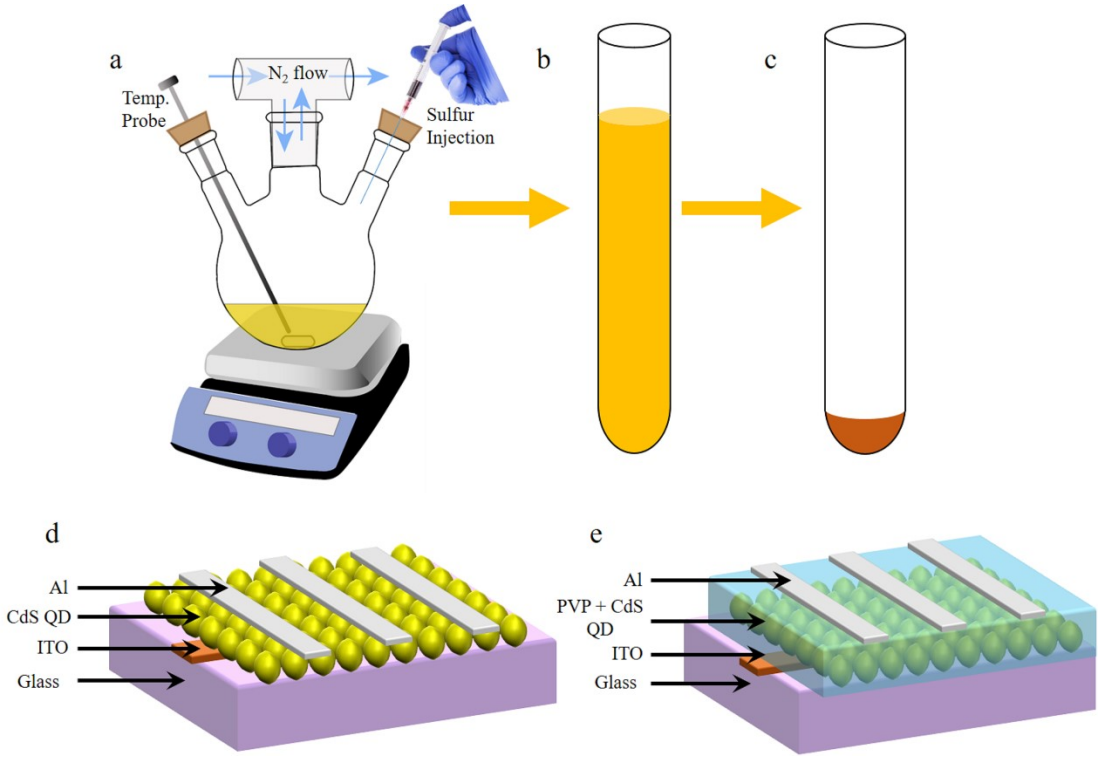

Fig. S1: The schematic diagram of synthesis procedure (a) the injection of the sulfur precursor into the Cd precursor solution. (b) The CdS solution was taken into a test tube for centrifugation, and a mixture of acetone and ethanol was added. (c) The CdS QDs powder precipitated at the bottom of the test tube after centrifuge. The schematic of the RRAM device fabricated using (d) pristine CdS quantum dots and (e) QDs and PVP at a ratio of 1:9. (c)

Characterization of CdS QDs:

Figure S2(b) shows the intensity of XPS with respect to binding energy over an energy range of 100 eV to 700 eV. The study shows intensity peaks for Cd_{3d} states and S_{2p} states, confirming the CdS material compositions. Some other peaks for carbon and oxygen are also existing, which have been observed for the ligand of QDs and the substrate of the film. The magnified XPS peaks for Cd_{3d} and S_{2p} states are shown in figures S2(c) and (d). The Cd atom shows the peak for $Cd_{3d,}$ which has $Cd_{3d5/2}$ and $Cd_{3d3/2}$ states at a binding energy of 404.8eV and 411.5eV, respectively. The data matched well with previously reported data. The intensity peak of $Cd_{3d3/2}$ is lower than that of $Cd_{3d5/2}$. The ratio of $Cd_{3d5/2}$ and $Cd_{3d3/2}$ is 1.3, which is nearly the same (1.5) as the metallic Cd atom. The lower ratio might be due to the influence of the N_{1s} state present in the ligand (OAm), which may have overlapped with the $Cd_{3d5/2}$ peak[1]. The peak of the sulfur atom due to the S_{2p} state can be observed at 161.3eV, as shown by the dotted line.

The determination of the bandgap using the optical absorption spectra using the popular method proposed by Tauc et al. is shown in figure S2(e). The absorption strength depends on the difference between photon energy and bandgap, and can be represented by the equation given below

$$\text{a.} \quad (\alpha h\nu)^{\frac{1}{s}} = A(h\nu - E_g) \tag{1}$$

The α, h, ν, A, and E_g are the absorption coefficient, Planck's constant, photon frequency, the slope of the absorption curve, and bandgap, respectively. The value of s changes with the nature of the transition of the semiconductor. In our case, the CdS QDs have a direct transition, for that, the value of s is ½. Using this method and fitting the data, the bandgap of the QDs has been found to be 3.02 eV.

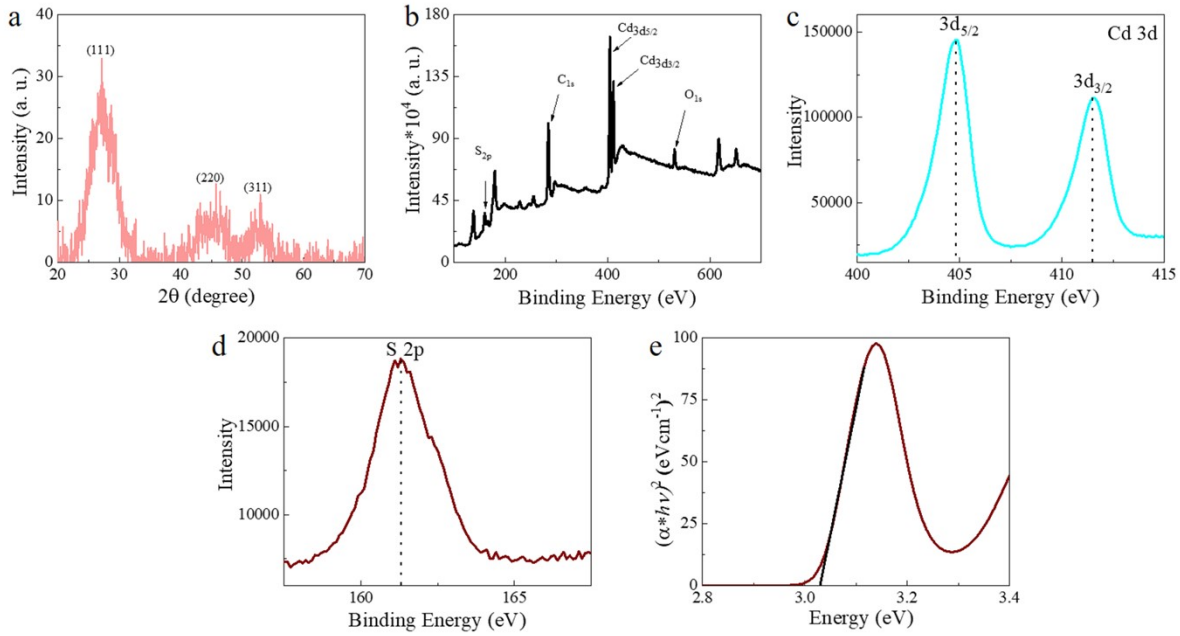

Fig. S2: (a) XRD pattern of CdS quantum dots taken in the 2θ range of 20° to 70°. (b) XPS with a full energy range of 100 eV to 700 eV to get the elemental compositions. The XPS for the states of (c) Cd $3d_{5/2}$ and $3d_{3/2}$ have peaks at a binding energy of 407 eV and 414 eV, respectively, and (d) S 2p state at 164 eV. (e) The Tauc plot was fitted to calculate the bandgap of CdS QDs.

Reference:

1 F. Weigert, A. Müller, I. Häusler, D. Geißler, D. Skroblin, M. Krumrey, W. Unger, J. Radnik and U. Resch-Genger, Combining HR-TEM and XPS to elucidate the core–shell structure of ultrabright CdSe/CdS semiconductor quantum dots, *Sci. Rep.*, 2020, **10**, 1–15.