High performance Organic Rectifier Diode for RF Energy harvesting obtained by Self Assembled Monolayer SAM functionnalization of Electrodes

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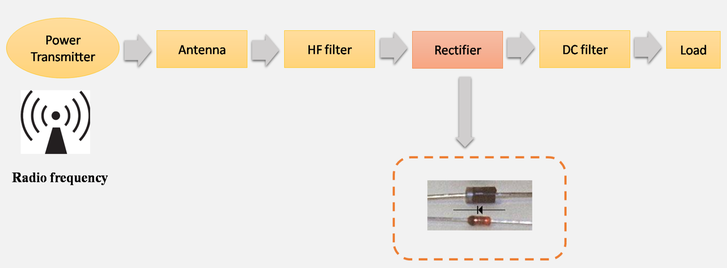
Introduction

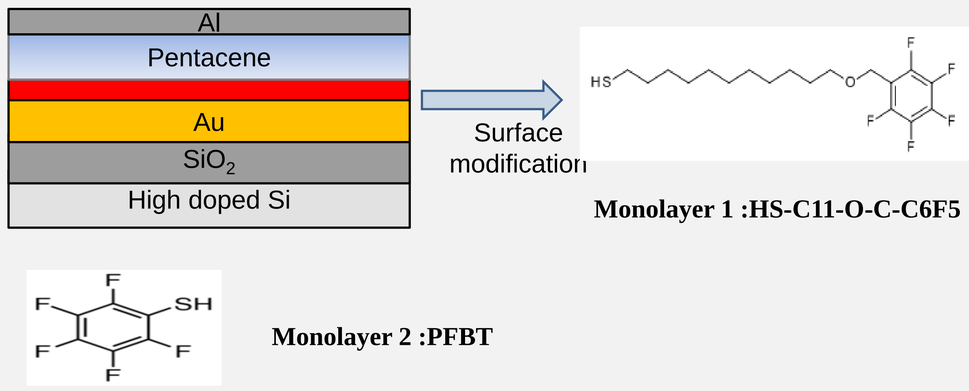
Organic diode rectifier for radio ferequency RF energy haversting have attracted a lot of attention these last decades owing to their flexibility, low cost and easy manufacturing process. But until now, the design of organic circuits capable to cover a wide frequency band (GSM 900 - 1800MHz) and WiFi (2.4 - 5 GHz) is a still a challenging work. In this work, we demonstrate that, using materials having good electrical properties , we can achieve a rectifier that can operate in higher frequency range.



Application : rectenna (rectifying antenna)

Experimental part

Diodes has been fabricated in vertical structure . The bare of gold has been treated with two different monolayers in order to reduce the injection barrier for holes



Monolayer 1 :HS-C11-O-C-C6F5

Monolayer 2 :PFBT

Physical analysis

The different SAM modified gold has been compared in terms of contact angle , the contact angles of bare gold measured are between 52° and 60°. After SAM treatment the contact angles increase to 84° - 87° which is corresponds to the theoretical values for the used SAM.

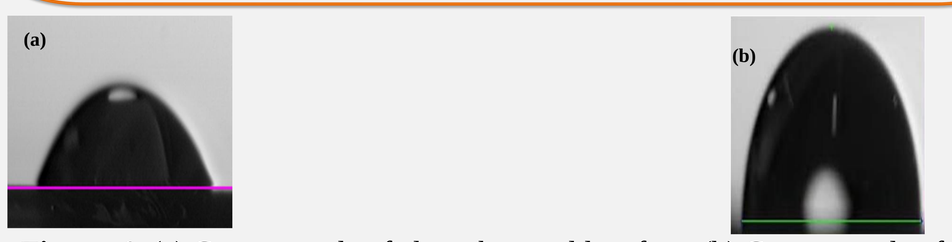


Figure 1. (a) Contact angle of clean, bare gold surface. (b) Contact angle of SAMs treated gold.

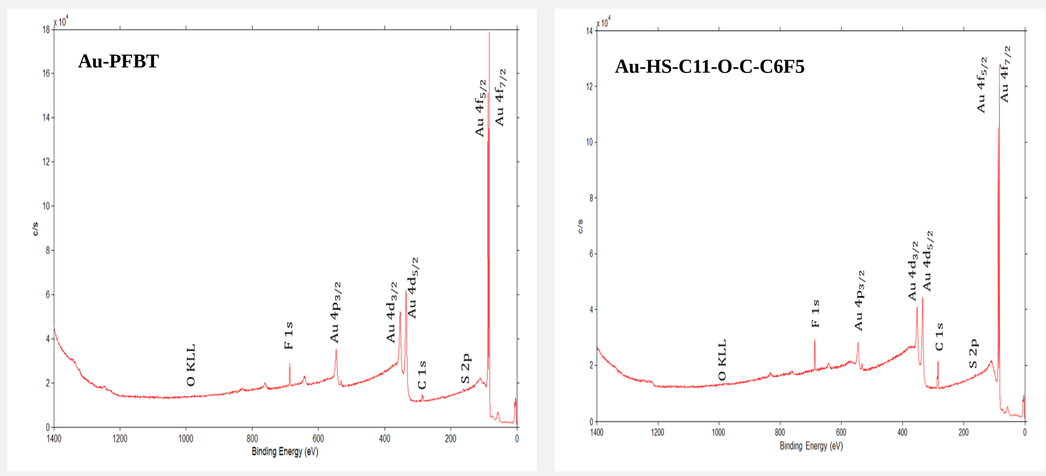


Figure 2. XPS measurements for gold treated with the two monolayers.

The XPS analysis also justify that the molecules has been successfully grafted on bare gold.

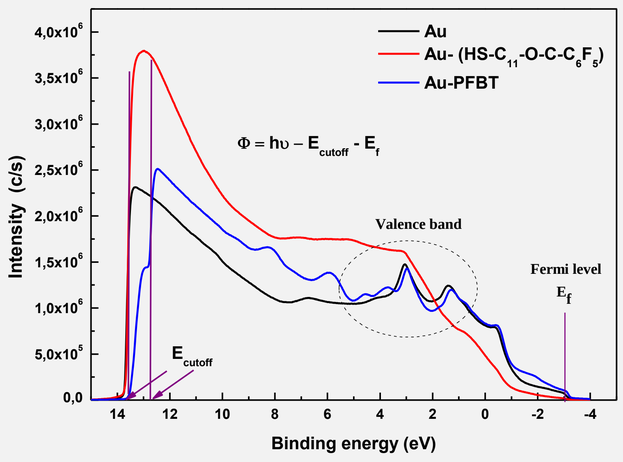


Figure 3. UPS spectrum

This analysis shows that untreated and treated gold with HS-C11-O-C-C6F5 have the same work function of 4.4 eV . With PFBT, the work function increases to a value of 4.69 eV.

Results & discussions

Static analysis

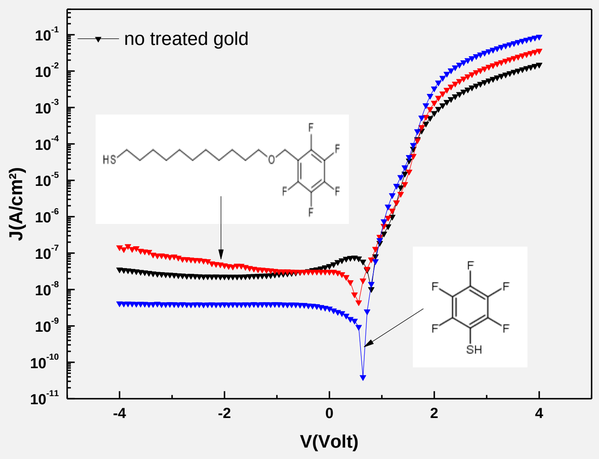


Figure 4. J-V characteristics of no treated and treated gold,

- High rectification ratio (up to 10^7) for the diode with PFBT coated Au.
- The turn on voltage is about 0.6 V.

dynamic analysis

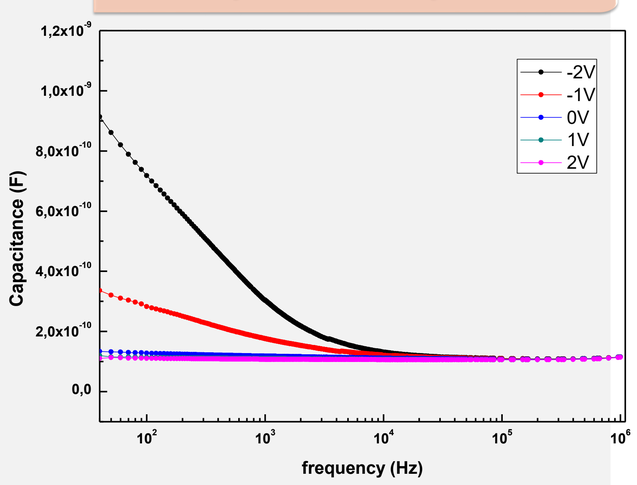


Figure 5. The capacitance as a function of the frequency

Frequency measurement indicate that the capacitance of the diode has a value of 120 pF and the serie resistance is about 78 Ω.

Simulation

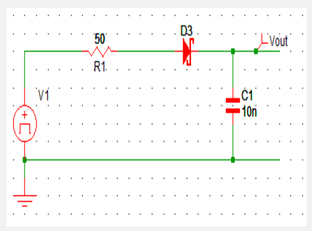


Figure 7. Circuit used in simulation.

- The simulation shows that in order to increase the frequency response of the diode , we should decrease the capacitance of the diode to about a few pF.

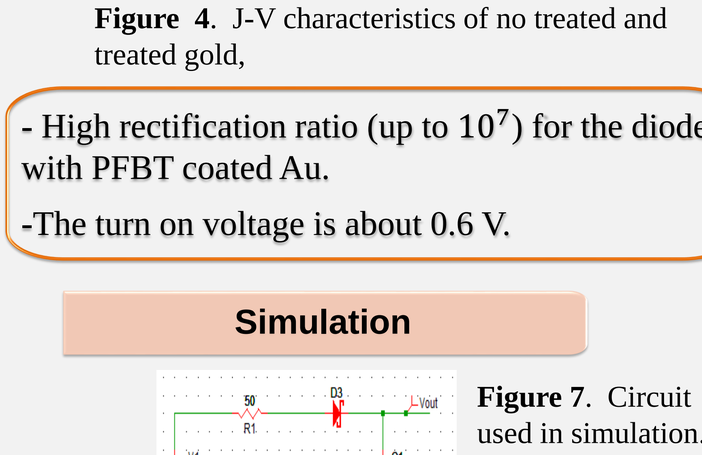


Figure 8. Results of the simulation at the frequency of 900MHz , 1.8 GHz and 2.4 GHz. (Cj = 1.5 pF)

Diodes with very low turn on voltage

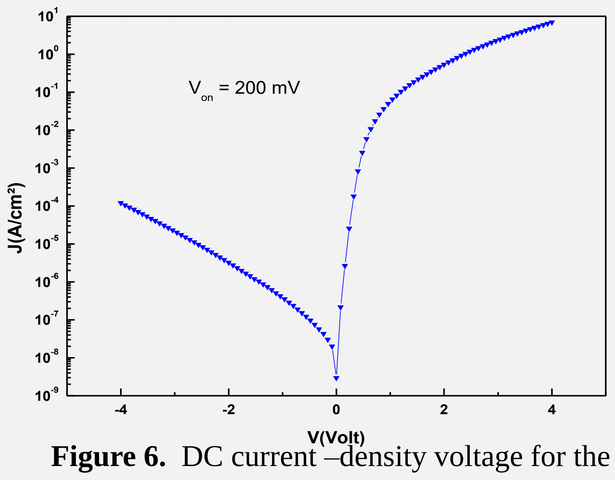


Figure 6. DC current –density voltage for the diode with low turn on –voltage.

- With controlling the thikness of pentacene we are able to fabricate diodes with a very low turn on voltage.

Conclusion

In this study, diodes with different SAM modified gold were fabricated and their electrical performances has been compared .The diodes with PFBT show the best electrical properties, and a high rectification ratio of 10^7 is obtained . With controlling the thkiness of pentacene , we have fabricated diodes with very low turn on voltage. The simulation shows that these diodes can operate at higher frequencies with an appropriate adaptive impedance matching circuits.

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