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GRAPHENE PAPER FOR APPLICATIONS IN FLEXIBLE ELECTRONICS

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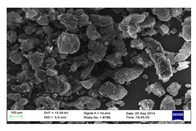
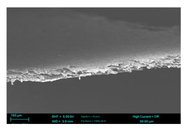
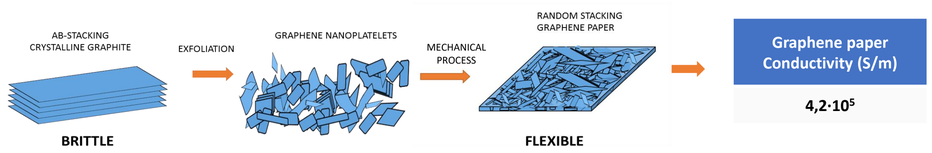
ABSTRACT

Thanks to its excellent mechanical, electrical and chemical properties, graphene is a promising material as a conductive flexible platform for new sustainable, flexible devices in many application fields, like wearable electronics, automotive and aeronautics, sensors, domotics, IoT and more [1-2].
Graphene Related Materials can be also reassembled in free-standing foils by mechanical compression, obtaining a flexible, electrically conductive, paper-like material called "graphene paper", which features a high electrical conductivity (1x10^5 S/m) and a mechanical stability even after a hundred of thousands bending times [1]. In this work, we report the advantage of using graphene paper for the realization of flexible heaters, NFC antennas, sensors and conductive tracks. The devices developed were prepared with easy, scalable and sustainable processes avoiding high temperatures annealing, chemical etching, pollutants and other high-energy consuming processes typical of metals. Further, graphene paper has a high compatibility with many substrates like textile, paper, plastic or composites, on which can be laminated with good adhesion widening the possible applications.

GRAPHENE PAPER FOR FLEXIBLE HIGH-PERFORMANCE METAL-FREE CONDUCTORS

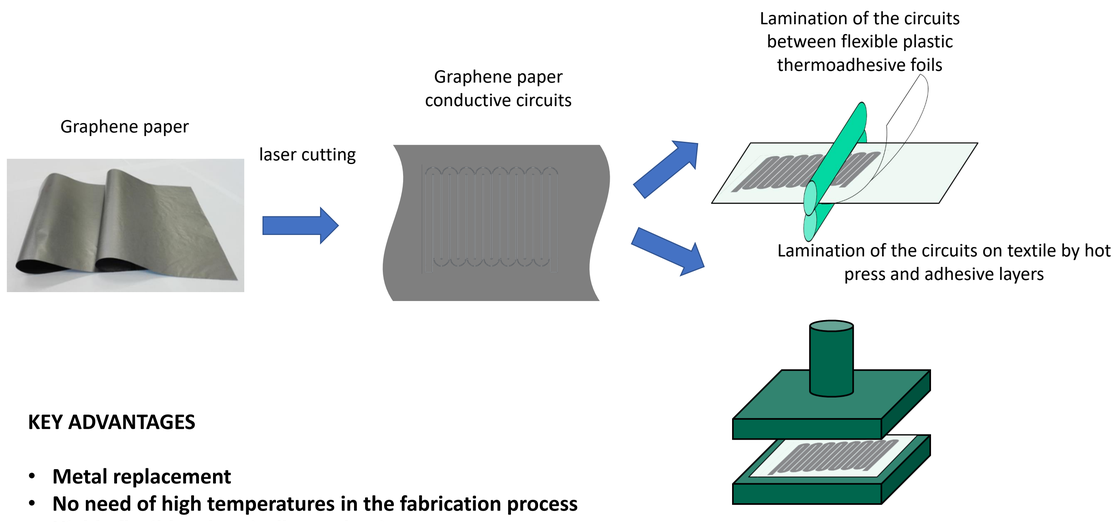






SOME EXAMPLES OF THE PERFORMANCE OF GRAPHENE-BASED INKS AS ELECTRICAL CONDUCTORS [3]

Device Tested	Electrical Conductivity (S/m)	Reference
Dipole antenna for RFID	**5,1·10^4**	K.Y. Shin, Advanced Materials, 23, (2011) 2113.
Dipole antenna	**4,3·10^4**	X.J. Huang, Applied Physics Letters, 106, (2015) #203105
Transmission lines, wideband antenna	**4,3·10^4**	X.J. Huang, 2D Materials, 3, (2016) #025021
Dipole antenna	**2,5·10^4**	J. S. Lee, Nanoscale, 7, (2015) 3668.
UHF RFID tag	**1,4·10^4**	M. Akbari, IEEE Antennas and Wireless Propagation Letters, 15, (2016) 1569
Conductive patterns	**1,0·10^4**	E.B. Secor, Advanced Materials, 26, (2014) 4533.
Conductive patterns (MoS2)	**3,0·10^3**	D.J. Finn, Journal of Materials Chemistry C, 2, (2014) 925
Conductive patterns	**870**	L. Huang, Nano Research, 4, (2011) 675
Emitting filament in light bulb	**16**	F.J. Tolle, Advanced Functional Materials, 22, (2012) 1136

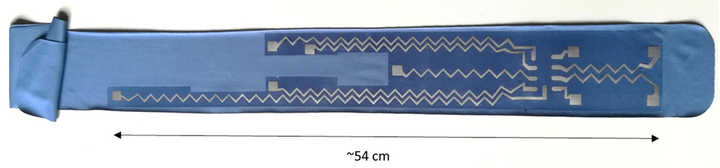
FABRICATION PROCESS OF THE FLEXIBLE GRAPHENE PAPER CIRCUITS AND ENCAPSULATION



KEY ADVANTAGES

- **Metal replacement**
- **No need of high temperatures in the fabrication process**
- **Highly flexible, electrically conductive**
- **versatile material easy to integrate in different substrates: textile, paper, plastic…**
- **Processes easy to scale up**
- **Environmentally friendly processes and devices**
- **Chemically and thermally stable devices**

FLEXIBLE AND STRETCHABLE GRAPHENE PAPER CONDUCTIVE TRACKS ON TEXTILE

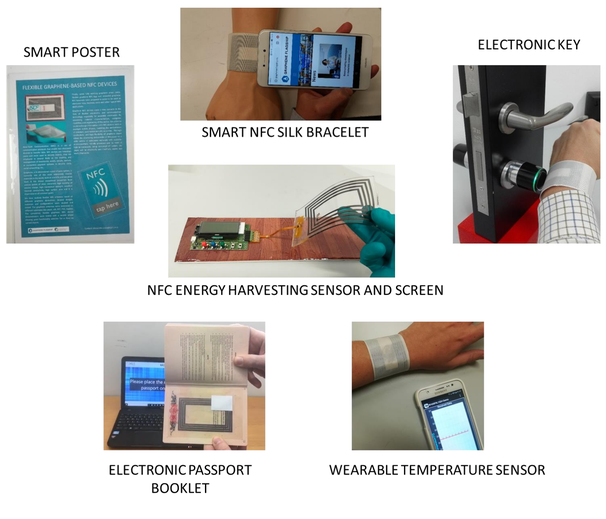


Graphene paper conductive tracks for a wearable sensing belt: conductivity not reduced even after 500 cycles at 20% strain.

FLEXIBLE CONDUCTIVE GRAPHENE PAPER TRACKS FOR BIO-SENSING


Graphene paper electrodes for biosensing laminated on PET and on cotton → for more info follow the oral talk on Wed 1st : *All-graphene flexible electrodes: novel platforms for wearable biosensing* – B. Zanfrognini

FLEXIBLE NFC GRAPHENE PAPER DEVICES

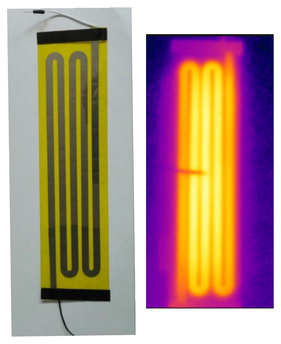


The NFC devices developed are one of the first examples of graphene based NFC applications and show the potential use of graphene for new green and wearable IoT applications. Graphene NFC antennas can be integrated in several flexible materials like fabric, paper, plastic for several applications. These graphene circuits provide a reliable, environmentally friendly alternative to metallic antennas, because they are flexible and highly electrically conductive, chemically and thermally stable.

A. Scidà et al., Materials Today 21 (2018), 223

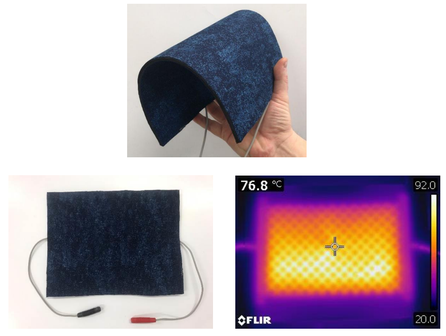
FLEXIBLE GRAPHENE PAPER HEATERS

INTEGRATED IN KAPTON



Flexible graphene paper heating modules encapsulated in kapton

INTEGRATED IN TEXTILE



Flexible graphene paper heating modules encapsulated in textile

CNR developed flexible graphene paper heaters integrated in kapton and textile.
The devices prepared show good functionality and uniform heating. The excellent thermal and electrical properties of graphene spread heat rapidly across graphene heating modules. Graphene heaters are chemically and thermally stable and prepared with a process scalable and environmentally friendly. Graphene-based heating modules can be easily integrated in many substrates suitable for aeronautical, automotive and wearable applications.

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REFERENCES

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