MICROSCOPE FOR TWISTRONICS AND SPINTRONICS STUDIES

TECNOLOGÍA PATENTADA

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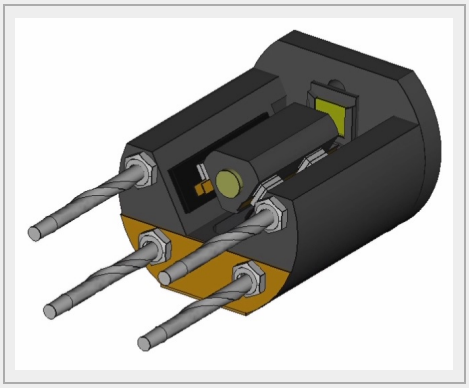
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RESUMEN

Researchers from the **Nanophysics group**, from the Department of Applied Physics at the University of Alicante, have developed a microscope whose structure and assembly allows twistronics and spintronics studies to be carried out jointly. Specifically, it allows the development of topography studies with atomic resolution, electronic transport studies and spin studies with the possibility of angular variation.

This invention, manufactured by **3D printing**, stands out for its versatility, easy assembly, low price and adaptability to different experimental techniques.

The group is looking for companies or institutions interested in acquiring this technology for its commercial exploitation.



INTRODUCCIÓN

Spintronics and twistronics are two research fields within **nanoelectronics**.

Spintronics is the emerging technology that uses both the electron's charge and its spin, while **twistronics** is defined as the novel science studying electronics as a function of the relative angle between two-dimensional layers. So far, the technical problem has been the impossibility, on the part of **Scanning Tunneling Microscopes (STM)**, of studying these two fields together.

In this sense, within spintronics, the most useful devices in terms of both scientific and industrial production have been **spin switches**, which are devices capable of blocking or allowing spin transport.

To date, multiple forms of spin-switches that can be controlled under external stimuli, such as light, magnetic field or electric field, have been studied. However, there is no known spin-switch that adjusts its electrical conductance by a mechanical twist.

DESCRIPCIÓN TÉCNICA

The invention consists of:

- A versatile microscope whose structure and assembly enables fixed-angle (Technique known as STM-BJ) and variable-angle (technique referred to by the inventors as Tw-STM-BJ) electron and spin transport studies, as well as surface topography studies at the atomic level (technique known as STM).
- This microscope also offers the possibility of creating a **spin-switch** device from a **mechanical** twist between two two-dimensional layers facing each other at their edges. In this way, this process would not only be cheaper and simpler, but also

more understandable from a scientific point of view.

This new measuring instrument, a **Scanning Tunneling Microscope (STM)**, has been manufactured using **3D printing**, which allows its quick and easy development. Therefore, the construction process of the instrument consists of 3 steps: design, printing and assembly. First, 3D design software is used to design each individual part. Subsequently, the designs are exported to a printing software, with which the printing characteristics are configured and, finally, each part is printed separately. The assembly phase is based on the assembly of all the parts, as well as the manufacture of the parts and their wiring.

This assembled structure makes it possible to modify the working configuration by changing some parts mechanically, quickly and easily. By fixing more parts on the structure or on the front support, the configuration can be modified so that the same microscope can be used to develop the three different techniques, i.e. the standard STM technique, which allows topography images to be obtained on electrically conductive surfaces; the STM-BJ technique, with which electronic transport can be measured; and the Tw-STM-BJ technique, which allows the study of electronic and spintronic transport in a system whose electrodes are capable of rotating, and with which a spin-switch controlled by a rotation can be performed *(see Figure 1)*.

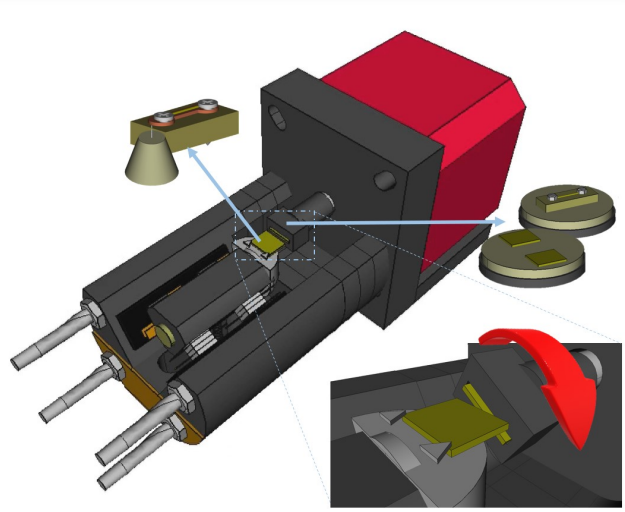


Figure 1: Illustration of the microscope together with its accessories which allow high versatility between STM, STM-BJ and TW-STM-BJ experimental techniques.

VENTAJAS Y ASPECTOS INNOVADORES

MAIN ADVANTAGES OF THE TECHNOLOGY

The main advantages of this technology are the following:

- It provides a solution to the problem of being able to have a device with which **combined** twistronics and spintronics studies can be carried out.
- It is an industrially manufacturable device that is easy to assemble, which makes it highly **versatile**, as it is possible to change the working technique simply by replacing some of its parts quickly and easily.
- The product is manufactured by a 3D printer, which **reduces costs and production times**.
- The 3D printer allows working with different types of recyclable polymers. In this case, polylactic acid or PLA has been chosen, which is derived from **natural, renewable and economical raw materials**.
- It does **not change its functionality** in the presence of magnetic fields. Generally, metal microscopes have magnetic impurities which cause magneto-construction effects, thus affecting topography or electrical/spin transport measurements.
- It can assist in the generation of dynamic, fixed-angle or variable-angle, proximity-tunneling gaps between facing and rotated two-dimensional electrodes. This makes this microscope suitable for use in **sequencing DNA, RNA, proteins, sugars or biomaterials**.

INNOVATIVE ASPECTS

The structure of a Scanning Tunneling Microscope (STM) has been reinvented in order to carry out innovative twistronics and spintronics studies together. This microscope has been manufactured using 3D printing, which is a major advantage over non-standardised microscopes on the market.

The use of this manufacturing method allows it to be developed easily, quickly and accurately, as well as solving the problems of machining, standardisation and reproducibility of this type of instrument. Specifically, Polylactic Acid (PLA) has been used as a manufacturing material, which allows the microscope to be economical and sustainable, unlike current titanium microscopes.

As mentioned above, all previous studies in the field of twistronics have been based on two-dimensional overlapping slides, however, such a configuration does not allow for a controlled spin-switch with mechanical rotation. Therefore, this twistronics proposal, with electrodes facing each other at the edge, is totally innovative and clearly offers the possibility of controlling the relative angle between the electrodes to form a spin-switch.

ESTADO ACTUAL

Several **prototypes** of this microscope are already in operation in the Nanophysics group's own laboratory, as well as in other collaborating research centres such as Yachay Tech University or the National University of Costa Rica.

APLICACIONES DE LA OFERTA

It is primarily aimed at the **nanoelectronics** sector, more specifically, companies manufacturing tunneling microscopes (STM).

COLABORACIÓN BUSCADA

The group is looking for companies or institutions interested in acquiring this technology for **commercial exploitation**.

DERECHOS DE PROPIEDAD INTELECTUAL

This technology is protected by **patent application**:

- Patent title: "*Microscopio para realizar estudios de twistrónica y espintrónica*".
- Application number: P202230548
- Application date: 21/06/2022

SECTORES DE APLICACIÓN (1)

Materials and Nanotechnology

IMÁGENES TÉCNICAS (1)

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