# Design and modeling of an electromagnet-based sputtering magnetron

Technologie du génie physique

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## Abstract

The static nature imposed by the use of permanent magnets in a magnetron sputtering process can be a significant drawback. In this regard, the implementation of electromagnets offers a promising solution, enabling straightforward modulation of the magnetic configuration. The main objective of this work is to develop a three-dimensional magnetic field acquisition software using the THM1176 3-axis Hall magnetometer. This software will allow precise measurements of the magnetic field configuration under varying coil currents. Following this, the project involves the mechanical design and partial fabrication of the sputtering magnetron system, preparing it for later assembly and characterization. Finally, the software is tested on a simplified setup consisting of a water-cooled copper pipe, with coil currents ranging from 0 to 200 A.

## Part 1: Design modeling



**Fig. 1** : 3D model of the electromagnet-based sputtering magnetron

## Research Process

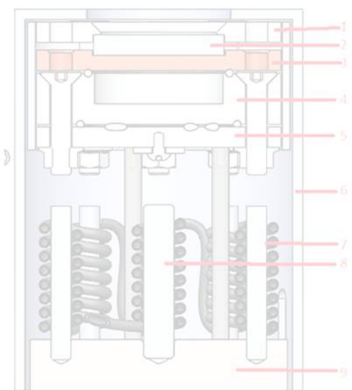
A three-axis stepper-motor table is used with a custom Python-based software to enable 3D magnetic field data acquisition, saving the data in a text file for later processing.

A second program is used for plotting and displaying vectoral magnetic field data from the first app. Permanent magnets are used for this phase

The electro-magnetron is then digitally designed and assembled using a CAD software. It consists of a magnetron-like system where the permanent magnets are replaced with 4mm inner diameter water-cooled copper pipe coils traversed by up to 400 A.

Final testing phase: a simplified coil is made from 4mm copper tubing, the water and electrical circuits are connected, magnetic data acquisition is then performed with varying currents, as well as a magnetic mapping.

## Part 2: Components of the magnetron



1: Sputtering target clamp.
2: Sputtering target (cathode).
3: Backing plate, which cools the target.
4: Aluminum plate with water cooling cavity.
5: Cooling system holder.
6: System hood (anode).
7: Water cooled peripheral coil.
8: Water cooled central coil.
9: Magnetron base plate

**Fig. 2**: Section view of the magnetron and its main components.

## Results

### 1. Influence of 1-turn coil current on the magnetic field intensity

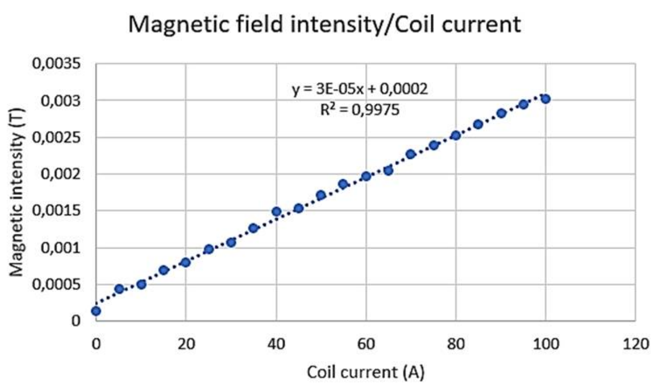


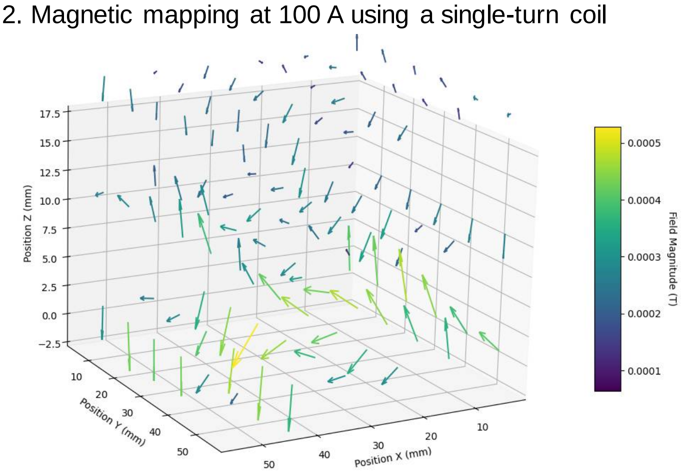

**Fig. 3**: Linear increasing of the magnetic field strength with the current flowing through the coil

**Two conclusions** can be reached for this test:

First, the current through the water-cooled coil is linearly related to the resulting magnetic field intensity. This expected behavior confirms the reliability of the measurements.

Then, a magnetic field intensity of 3 mT was generated using a 100 A current in a single-turn coil, three centimeters in diameter, without a ferromagnetic core. This result suggests that the setup illustrated in Figure 1 has the potential to produce substantially stronger magnetic fields in future applications.

### 2. Magnetic mapping at 100 A using a single-turn coil




## Conclusions

- **Using our system, we identified a set of parameters that were optimal to efficiently pulverizing a titanium target.**
- **The HiPIMS plasma generation method is significantly more efficient than DC plasma generation.**

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