Advanced Research Activities in High Magnetic Fields at the FTMC

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A brief overview of the high pulsed magnetic field facilities and advanced research at the Center for Physical Sciences and Technology (FTMC) is presented.

The main goal of such activities is to develop functional materials with distinct properties starting from the fabrication technologies up to device prototypes. Significant efforts are being made to develop fabrication technologies — such as MOCVD, magnetron sputtering, and pulsed laser deposition — to create advanced thin films and nanostructures. These materials, including ferromagnetic oxides, Heusler alloys, high-temperature superconductors, and 2D semiconductors like graphene, are tailored for specific applications in spin valves, magnetic field sensors, biosensors, high current limiters, and many other devices.

One of the examples – development of high pulsed magnetic field sensors. Advanced scientific and industrial equipment requires magnetic field sensors with decreased dimensions while keeping high sensitivity in a wide range of magnetic fields and temperatures. However, there is a lack of commercial sensors for measurements of high magnetic fields. It is demonstrated how tuning of the nanostructure and chemical composition of thin polycrystalline ferromagnetic oxide films (manganites) could result in a remarkable colossal magnetoresistance (CMR) up to megagauss over a large range of temperatures allowing to measure magnitude of magnetic field independently of magnetic field direction (CMR-B-Scalar sensors).

Compact low-cost pulsed magnetic field generator that produces magnetic pulses of 0.25-1 ms duration with amplitudes up to 40 T is used for on-going research of the magnetoresistive effects in various materials. It is demonstrated how specially designed nanostructured lanthanum manganite films and their hybrid structures with few-layer graphene could be used for the development of magnetic field sensors measuring the magnitude of magnetic field and its direction in respect to the sensor’s plane.

A system combining short nanosecond duration strong electric field pulse synchronized at a peak of millisecond duration magnetic field pulse is presented. Nanosecond electric field pulses are used to study intrinsic electronic properties and tunnelling effects in nanostructured films and magnetic tunnel junctions while minimizing Joule heating. Pulsed magnetic field allows to study the combined magnetic and electric properties in semi-stationary conditions of magnetic field.

The custom-build pulsed magnetic forming and welding system used for the investigation of microsecond duration magnetic field processes is presented. The possibility to use CMR-B-scalar sensors for non-destructive evaluation of metal welding quality is demonstrated.

Finally, future perspectives of high magnetic field sensors applications are discussed.