Modifications of the $Bi_2Ca_2Co_2O_{8-\delta}$ thermoelectric properties by controlling the microstructure

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Abstract – The $Bi_2Ca_2Co_2O_{8-\delta}$ compound has been obtained by coprecipitation, sol-gel and spray drying methods. The microstructure of the samples directly affects the thermoelectric properties. Indeed for the sample prepared by spray drying, the electrical conductivity increases by a factor of 2. The influence of the addition of silver particles on the Seebeck coefficient and the electrical properties will also be presented in more details at the conference.

Thermoelectric (TE) power generation, in which waste heat is converted into electricity, is a significant alternative technology for producing energy while reducing the use of fossil fuel and the emission of greenhouse gases. In TE materials, heat is converted into electricity by the Seebeck and the Peltier effects; the energy conversion is straightforward: it does not involve moving parts and does not generate waste products. The conversion efficiency is defined by the $ZT= S^2\sigma/\kappa$ value, where S is the Seebeck coefficient, σ the electrical conductivity and κ the thermal conductivity. The thermoelectric oxides are promising candidates due to their chemical stability in air at temperatures up to 700°C or even higher for the most stable phases [1,2].

The $Bi_2Ca_2Co_2O_{8-\delta}$ (BCCO) compound belongs to this family of lamellar oxides. Thermoforging and substitutions on the Bi and the Ca sites have been employed to improve the TE properties [3,4]. In our case, we have used chimie douce preparation methods to improve the BCCO TE properties (the coprecipitation, the sol-gel and the spray drying methods). Indeed these techniques allow a modification of grain size and grain size distribution, which directly affects the compacting of the ceramic and therefore the electrical and thermal conductivities.

X Ray Diffraction results confirm that all samples display the typical $Bi_2Ca_2Co_2O_{8-\delta}$ structure [5], i.e. a lamellar structure composed of two types of blocks: a CoO_2 layer formed by edge sharing CoO_6 octahedra alternates with a Rock-Salt (RS) block formed by four layers (CaO-BiO-BiO-CaO).

Figure 1 shows that the spray drying technique leads to a reduction of the size and a better distribution of BCCO grains than with the solid state reaction. This feature induces a large increase of the electrical conductivity value of the sample (Figure 2a). At the same time, the Seebeck coefficient remains unchanged. Consequently, the power factor ($P=S^2\sigma$) increases (Figure 2b).

A comparison with sol-gel samples and an investigation of the influence of the addition of silver particles on the Seebeck coefficient and the electrical properties will also be reported.

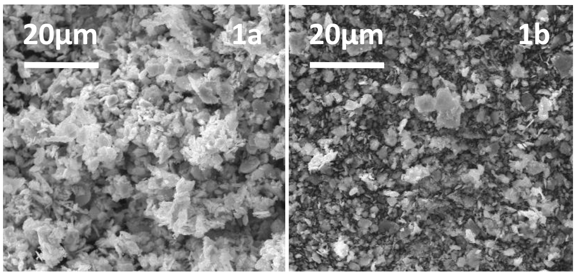

Figure 1: SEM images of the $Bi_2Ca_2Co_2O_{8-\delta}$ powders obtained by a) solid state reaction b) spray drying method.

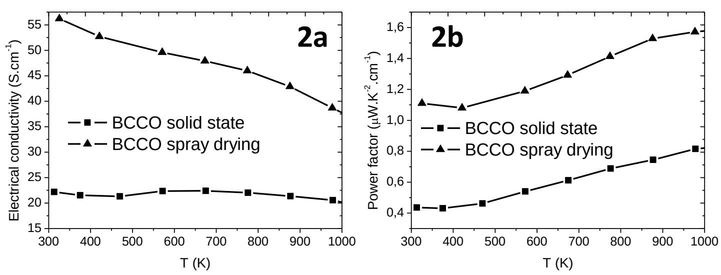

Figure 2: a) Electrical conductivity and b) thermopower of the $Bi_2Ca_2Co_2O_{8-\delta}$ compounds obtained by solid state reaction and spray drying method.

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