

# Combinatorial study of ceramic tape-casting slurries

Zhifu Liu<sup>\*</sup>, Yiling Wang, Yongxiang Li<sup>\*</sup>

The Key Lab of Inorganic Functional Materials and Devices, Shanghai Institute of Ceramics, Chinese Academy of Sciences, 1295 Dingxi Road, Shanghai 200050, China

## 1. Source materials

X7R ceramic powder (GC-292M) with a mean particle size of 0.6  $\mu\text{m}$  was bought from Sinocera Co. (Dongyin, China). The absolute ethyl alcohol ( $\geq 99.7\%$ ) was from Shanghai Zhengxing No.1 Chemical Plant. The ethyl-acetate (AR,  $\geq 99.5\%$ ) was supplied by Shanghai LingFeng Chemical Reagent Co. Ltd. Poly-vinyl-butyral (PVB) (B06SY) was from Chang Chun Petrochemicals Co. Ltd, Taiwan. Polyethylene-400 (PEG400) (CP, MW=380-430) and Glyceryl triacetate were from Sinopharm Chemical Reagent Co. Ltd. Butyl-benzyl-phthalate (BBP) (98%) was from Alfa Aesar a Johnson Matthey Company.

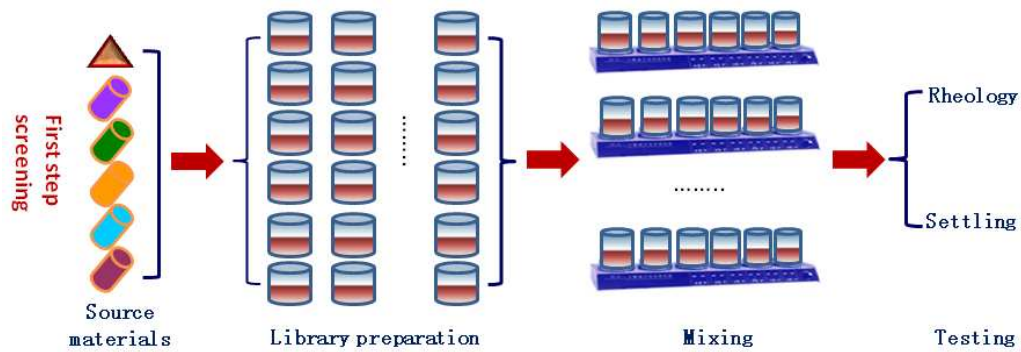
## 2. Library design

The ceramic tape-casting slurry is a complex system of ceramic powder, solvent, binder, dispersant, plasticizer, etc. Here, the composition of the slurry is written as  $\text{Cera}_m\text{Sol}_n\text{A}_w\text{B}_x\text{C}_y\text{D}_z$ , where “Cera” represents the ceramic powder; “Sol” represents the solvent; “A” represents the PVB binder; “B” represents plasticizer I (PEG400); “C” represents plasticizer II (BBP); “D” represents the dispersant (Glyceryl triacetate); m, n, w, x, y, and z indicate the amount of each component. In this work, we focus on the optimization of the organic composition of the slurry. So we fix the amount of ceramic powder (Cera) and the solvent (Sol). In the first step of screening, 60 g ceramic powder ( $m=60$ ) and 20 g

solvent ( $n=20$ ) were used for each sample. For the amounts of PVB binder, PEG400, BBP and the dispersant,  $w = 2, 3, 4$ ;  $x = 1, 2, 3$ ;  $y = 0, 1, 2$ ;  $z = 0.5, 1$  (the unit is g for all) were selected, respectively. So the combinatorial library contains 54 samples for the first stage of screening. The following lists the slurry library compositions (Cera<sub>60</sub>Sol<sub>20</sub><sup>-</sup>):

$A_2B_1C_0D_{0.5}$	$A_2B_1C_0D_1$	$A_2B_1C_1D_{0.5}$	$A_2B_1C_1D_1$	$A_2B_1C_2D_{0.5}$	$A_2B_1C_2D_1$
$A_2B_2C_0D_{0.5}$	$A_2B_2C_0D_1$	$A_2B_2C_1D_{0.5}$	$A_2B_2C_1D_1$	$A_2B_2C_2D_{0.5}$	$A_2B_2C_2D_1$
$A_2B_3C_0D_{0.5}$	$A_2B_3C_0D_1$	$A_2B_3C_1D_{0.5}$	$A_2B_3C_1D_1$	$A_2B_3C_2D_{0.5}$	$A_2B_3C_2D_1$
$A_3B_1C_0D_{0.5}$	$A_3B_1C_0D_1$	$A_3B_1C_1D_{0.5}$	$A_3B_1C_1D_1$	$A_3B_1C_2D_{0.5}$	$A_3B_1C_2D_1$
$A_3B_2C_0D_{0.5}$	$A_3B_2C_0D_1$	$A_3B_2C_1D_{0.5}$	$A_3B_2C_1D_1$	$A_3B_2C_2D_{0.5}$	$A_3B_2C_2D_1$
$A_3B_3C_0D_{0.5}$	$A_3B_3C_0D_1$	$A_3B_3C_1D_{0.5}$	$A_3B_3C_1D_1$	$A_3B_3C_2D_{0.5}$	$A_3B_3C_2D_1$
$A_4B_1C_0D_{0.5}$	$A_4B_1C_0D_1$	$A_4B_1C_1D_{0.5}$	$A_4B_1C_1D_1$	$A_4B_1C_2D_{0.5}$	$A_4B_1C_2D_1$
$A_4B_2C_0D_{0.5}$	$A_4B_2C_0D_1$	$A_4B_2C_1D_{0.5}$	$A_4B_2C_1D_1$	$A_4B_2C_2D_{0.5}$	$A_4B_2C_2D_1$
$A_4B_3C_0D_{0.5}$	$A_4B_3C_0D_1$	$A_4B_3C_1D_{0.5}$	$A_4B_3C_1D_1$	$A_4B_3C_2D_{0.5}$	$A_4B_3C_2D_1$

### 3. Library preparation and characterization



**Figure S1** Diagram of the slurry library preparation processes for the first step screening.

Plastic bottles with cover labeled by  $A_wB_xC_yD_z$  ( $w = 2, 3, 4$ ;  $x = 1, 2, 3$ ;  $y = 0, 1, 2$ ;  $z = 0.5, 1$ ) were used as the container of the slurry library samples. The ceramic power was weighted and put into the bottles first. After adding solvent and dispersant using pipette, the labeled bottles were put

onto six-position magnetic stirrs for mixing. Nine six-position magnetic stirrs were used for preparing the slurry library parallel (Figure s1). The samples were mixed for 4 h firstly and then 10 h after the binder and plasticizers were added

For the first step screening, the rheology and sedimentation properties were tested. The viscosity and shear strength of the samples were measured using a NDJ-79 (CNSHP, China) rheometer in sequence. The stability of the slurries was checked by sedimentation experiment. In detail, the slurries were put in glass bottle (2 cm in inner diameter) stationary for one month and then the volume ratio of the uniform slurry part was calculated by  $V_{\text{slurry}}/(V_{\text{suspension}}+V_{\text{slurry}}+V_{\text{precipitant}})\times 100\%$  (Figure S2). The higher  $V_{\text{slurry}}$  value, the better slurry stability.



**Figure S2** Photograph of the slurry library for sedimentation experiment.

#### 4. Facilities and procedures for the second step screening



**Figure S3** Facilities and procedures for second step screening.