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(12) RATE PHENOMENA IN A SLAG RESISTANCE ELECTRIC FURNACE (Miscellany)

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1.　ガスーメタル反応

プラズマと金属との反応による超微粒子および通常の低真空下における加熱蒸発による超微粒子との発生速度を比較する．これらの事実より，前者による超微粒子の発生速度は，温度，圧力，金属の蒸気圧の外に金属とプラズマとの反応が強く関与していることを示す．

一種の強制蒸発現象と考えている（超微粒子の製造原理）．

2.　製 造 装 置

製造装置は対象とする超微粒子の種類によって，それぞれ異なるが，大別すると竪型と横型があり，それぞれ放電電極も単数から複数，捕集部も単，複，があり，さらにグローブボックスの有無およびガス循環機構の有無などから構成されたものである．

複数電極を使用することで２種類以上の異なる材料を同時に蒸発させることができ，宇宙の無重力の助けを借りなくても比重の大きく異なる金属とセラミックスの均一混合超微粉を作製できる（例えば Ag＋TiN）．

3.　プラズマガス種と生成超微粒子種

水素プラズマと金属との反応は主として金属超微粒子の作製に使用されるが，酸化物，炭化物，ほう化物など SiC, LaB_6 の作製にも利用される．窒素プラズマは窒素との親和力の大きい金属にのみ適用可能であるが，貴金属の場合には同プラズマで超微粒子化ができる．

4.　超微粒子の反応性とその応用

水素プラズマにより作製した金属超微粒子（貴金属は除く）は酸化・窒化反応には極めて活性であり，室温においても空気と激しく反応し燃焼する．大気中で取り扱う場合には，粒子表面に薄い酸化皮膜を生成するような徐酸化処理が必要となる．逆に超微粒子の活性状態を利用して低温で難焼結性材料をも焼結可能である（Al 超微粒子の窒化反応による AlN 焼結体の作製）．

金属超微粒子の焼結挙動，触媒材料開発，溶接材料開発（金属―セラミックスの接合）などについて述べる．

(12)　RATE PHENOMENA IN A SLAG RESISTANCE ELECTRIC FURNACE

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Three types of electric furnaces are used in metallurgy: Open arc furnaces (OAF) used to melt iron scrap, submerged arc furnaces used in ferro alloy smelting, and slag resistance electric furnaces (SRF) where the electrodes are submerged into the slag layer. It is believed that the SRF furnaces offer a great potential for conventional smelting and slag－cleaning operations as well as for new applications such as the recycling of metallurgical dusts and continuous ironmaking from prereduced iron and from scrap.

The objective of current research work at Columbia is to understand better the rate phenomena taking place in a SRF furnace, such as the generation and distribution of heat in the molten bath and thus advance the design and operating control of such furnaces.

The work done to date has produced correlations of the slag electric resistivity as a function of slag composition. The bath resistance between electrodes was then represented as

$$R = f_g \cdot \rho_s$$

where

f_g : geometric factor

ρ_s : slag resistivity

By means of resistance measurements in a low－temperature model of the SRF, a correlation was developed of the geometric factor as a function of electrode diameter, depth of immersion and other geometric factors in the furnace. The correlation showed that, in addition to slag resistivity, the electrode resistance was affected mostly by the inter face area between immersed electrode and slag.

By modifying a commercial fluid flow simulation program (FIDAP), a three-dimensional mathematical model was developed of mass and heat flow in a SRF furnace. The model results showed that the electromagnetic forces are negligible in comparison to the thermal buoyancy force. The highest velocities in the bath were near the furnace walls and amounted to about 17 cm/s. The highest temperature zones were around the electrodes and in the delta region between electrodes. These results were in agreement with the geometric factor predictions.

Future work at Columbia University will include further development of this model as well as tests in a 60 kW computer–controlled experimental SRF furnace.