A gate drive circuit for gate-turn-off (GTO) devices in series stack

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Abstract

A gate-turn-off (GTO) switch is under development at the Advanced Photon Source as a replacement for a thyratron initial switch in high power pulsed applications [1]. The high voltage in the application requires multiple GTOS connected in series. One component that is critical to the success of GTO operation is the gate drive circuit. The gate drive circuit has to provide fast high-current pulses to the GTO gate for fast turn-on and turn-off. It also has to be able to operate while floating at high voltage. This paper describes a gate drive circuit that meets these requirements.

1 INTRODUCTION

The relatively low voltage ratings of GTO devices compared to thyratrons require the series connection of these devices when used as replacement in certain thyratron applications. For this series configuration, a basic requirement is a gate driver circuit that can be operated at a high floating potential.

The gate current requirement of the GTO used in the study, Westcode WG 1004OR36, is listed in Table 1. The turn-on gate current has two components, a fast initial pulse and a constant component. The leading edge portion of the current pulse is two to three times the value required to sustain the on state of the device. The high initial current is needed to supply charge quickly into the nonlinear gate capacity of the GTO in order to reduce its turn-on time. The recommended amplitude by Westcode is between 70 and 100 amperes. After the GTO device is turned on, a substantial amount of gate current is still needed to maintain a low on-state resistance and, hence, a low voltage drop across the GTO's anode and cathode. During the turn-off process, a large current is required in the reverse direction to remove charges from the junction and restore the forward-voltage-blocking capability. The amplitude of the turn-off gate current can be much greater than that required for turn-on, depending on the current at which the GTO is trying to turn off. The greater the turn-off current, the greater the amplitude has to be. The speed of the GTO'S recovery depends on how fast the charge is removed.

A low-leakage-inductance pulse transformer, which also provides the high voltage isolation, can be used to supply the leading edge portion of the current pulse. The current level needed to keep the on-state resistance low for the duration of the on state, however, will most likely be provided by some other means if this duration is in many microseconds.

2 DIRECT GATE DRIVE CIRCUIT

A direct gate drive circuit has been developed for the GTOS. As shown in Figure 1, the output of the drive circuit is connected directly to the GTO gate without a pulse transformer. The drive circuit is divided into two sections, a low voltage section and a high voltage section. The low voltage section contains a fly-back type DUCD converter that provides the required power for the high voltage section. The high voltage section has the control

Figure 1: Block diagram of the GTO gate drive circuit

RI = 0.2Ω, R2 = 0.5Ω, C1 = 220pF, C2 = 4.4μF, R3 = 3(×2, R4 = 0.25Ω, C3 = 220pF, C4 = 6.6μF

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Synthesis and Characterization of Nanophase Zirconia: Reverse Micelle Method and Neutron Scattering Study

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Introduction
Zirconia is an important transition-metal oxide for catalytic applications. It has been widely used in automotive exhaust treatment, methanol synthesis, isomerization, alkylation, etc.\cite{1}. Nanophase materials have unique physicochemical properties such as quantum size effects, high surface area, uniform morphology, narrow size distribution, and improvement of sintering rates\cite{2}. Microemulsion method provides the means for controlling the microenvironment under which specific chemical reactions may occur in favoring the formation of homogeneous, nanometer-size particles. In this paper, we report the synthesis of nanophase zirconia and the characterization of the microemulsions as well as the powders by small- and wide-angle neutron scattering techniques.

Synthesis
A 0.1 M Sodium bis(2-ethylhexyl) sulphonate (AOT) in a fully deuterated Toluene solvent was first prepared. Appropriate amounts of D\textsubscript{2}O were added to this AOT/C\textsubscript{6}D\textsubscript{5}CD\textsubscript{3} solution, forming microemulsions at different molar ratios (w) of D\textsubscript{2}O to AOT (0 \leq w \leq 20). Another two microemulsion systems were prepared, one by adding a 0.2 M ZrOCl\textsubscript{2} in D\textsubscript{2}O and the other by adding 22\% \text{NH}_4\text{OH} aqueous solution, to the AOT/Toluene solution while maintaining the same w values. Finally, the microemulsions containing ZrOCl\textsubscript{2} and \text{NH}_4\text{OH} of the same w value were mixed together. All solutions were stirred continuously during mixing. The reacted solutions were centrifuged and the precipitant was washed repeated by alcohol and deionized water. The gel was first dried at 120\° C in vacuum and then calcined at 550\° C for several hours.

Neutron Scattering Characterization
Neutron experiments were performed at the Intense Pulsed Neutron Source (IPNS) of Argonne National Laboratory. Four microemulsion systems of different values of w, i.e., D\textsubscript{2}O/AOT/C\textsubscript{6}D\textsubscript{5}CD\textsubscript{3}, ZrOCl\textsubscript{2} in D\textsubscript{2}O/AOT/C\textsubscript{6}D\textsubscript{5}CD\textsubscript{3}, \text{NH}_4\text{OH} in AOT/C\textsubscript{6}D\textsubscript{5}CD\textsubscript{3}, and ZrOCl\textsubscript{2} reacted with \text{NH}_4\text{OH} in AOT/C\textsubscript{6}D\textsubscript{5}CD\textsubscript{3},
were characterized by small-angle neutron scattering (SANS) at room
temperature over a range of wavevectors of 0.0035-0.8 Å⁻¹. In the
D₂O/AOT/C₆D₅CD₃ system, monodispersed reverse micelles were observed,
and the size was found to increase linearly with increasing w for 2.5 < w < 20.
With the addition of ZrOCl₂ and NH₄OH, the reverse micelle sizes decrease by
~35 and ~22%, respectively, as compared to those in the D₂O/AOT/C₆D₅CD₃
system. The mixed microemulsions contain reverse micelle sizes that fall
between the values of the pre-mixed solutions. All the reverse micelles exhibit
uniform size and spherical shape. The AOT aggregation numbers and the
concentration of the reverse micelles in the four systems as a function of w were
derived. In addition, the crystal structure of nanophase zirconia obtained under
different preparing conditions was determined by neutron diffraction
measurements also performed at IPNS.

The particle size and its distribution, surface area, crystal structure, fractal
dimension and thermal stability of nanophase zirconia prepared by the reverse
micelle method are compared with those from other synthesis methods such as
the sol-gel and hydrothermal techniques[3].

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References
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