

Characterization of Electrodes for Deep Brain Stimulation

Ute Schreiber¹, Ulrike Gimsa², Jan Gimsa³, Ursula van Rienen¹

1 University of Rostock, Faculty of Computer Science and Electrical Engineering, Institute of General Electrical Engineering, Albert-Einstein-Str. 2, D-18059 Rostock, Germany

2 University of Rostock, Medical Faculty, Department of Neurology, Gehlsheimer Str. 20, D-18147 Rostock, Germany

3 University of Rostock, Department of Biology, Chair of Biophysics, Gertrudenstr. 11A, D-18057 Rostock, Germany

e-mails: ute.schreiber@~, ulrike.gimsa@med.~, jan.gimsa@~, ursula.van-rienen@uni-rostock.de

Several neurological diseases, such as Parkinson's disease, are characterized by a synchronization of ensembles of oscillatory neurons in particular brain areas, where the normal electric activity is supposed to be uncorrelated. The electric stimulation of these brain neurons with pulsed signals, the so-called Deep Brain Stimulation (DBS), counteracts the symptoms of these diseases. Despite its therapeutic application, the mechanisms of DBS and its effect on the neuronal activity are still not fully resolved yet.

In DBS, different parameters can be varied, e.g. the way multipolar electrodes are driven (unipolar, bipolar, ...), the pulse width, the frequency or the signal amplitude. A very important variable is the geometry of the implanted electrodes. As geometry determines the field in the tissue, cell damage could be inflicted if the field strength around the electrode is too high.

Characterization of the electrodes for DBS is necessary to allow for a safe and reproducible application of DBS with respect to the applied voltage or current in a given external medium. In this paper, cell constants, i.e. geometry factors relating the electrode impedance to the specific medium conductivity, were calculated to determine the electrode voltage for a given stimulation current. Nevertheless, for electrodes of the same cell constant but of different geometry, current and field distributions may be very dissimilar. We found geometry-dependent limiting values of the stimulation current, above which electric tissue damage may occur. These values limit the reach of the stimulation signal for a given electrode geometry.