separation column. The column would enable separation and concentration of individual species, which would then be detected and identified at the column outlet by use of NESS.

This work was done by Brian Hunt, Michael Bronikowsky, Eric Wong, Paul Von Allmen, and Fabiano Oyafuso of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-42251, volume and number of this NASA Tech Briefs issue, and the page number.

Electron-Spin Filters Would Offer Spin Polarization >1

Net spin flux could be generated with little net electric current.

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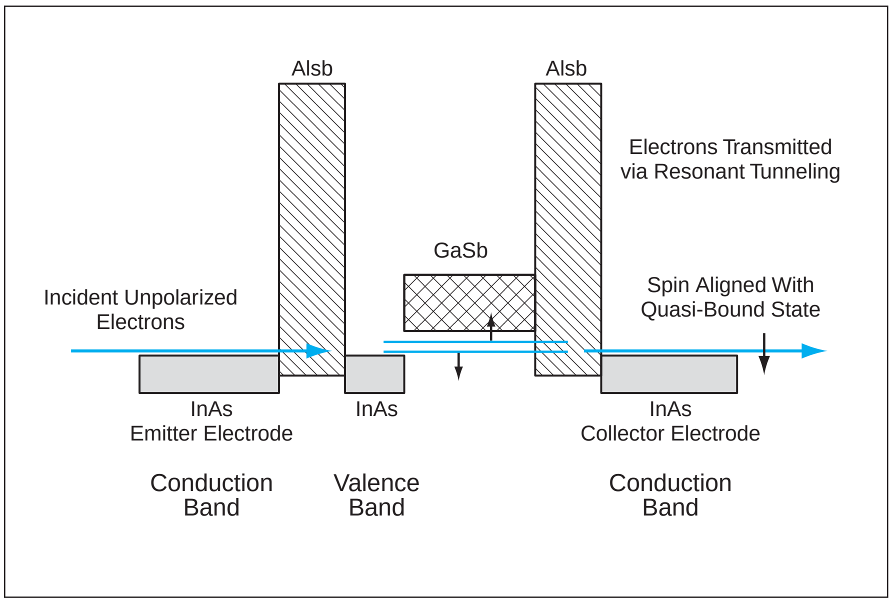
A proposal has been made to develop devices that would generate spin-polarized electron currents characterized by polarization ratios having magnitudes in excess of 1. Heretofore, such devices (denoted, variously, as spin injectors, spin polarizers, and spin filters) have typically offered polarization ratios having magnitudes in the approximate range of 0.01 to 0.1. The proposed devices could be useful as efficient sources of spin-polarized electron currents for research on spintronics and development of practical spintronic devices.

The polarization ratio in question — denoted the current spin polarization — is a standard measure of efficiency of a spin-polarizing device. It is defined in terms of current densities along a given coordinate axis, by means of the following equation:

$$P_J = (J\uparrow - J\downarrow) / (J\uparrow + J\downarrow),$$

where $J\uparrow$ is current density of electrons in the "up" spin state and $J\downarrow$ is the current density of electrons in the "down" spin state. If $J\uparrow$ and $J\downarrow$ can be made to have opposite signs — in other words, if electrons in opposite spin states can be made to move in opposite directions — then, as desired, it is possible to obtain $|P_J|>1$. By making $|P_J|>1$, one would make it possible to obtain a net spin flux with little net electric current.

A spin-polarizing device according to the proposal would be based largely on the same principles as those of the devices described in "Electron-Spin Filters Based on the Rashba Effect" (NPO-30635), *NASA Tech Briefs*, Vol. 28, No. 10 (October 2004), page 58. To recapitulate: The Rashba effect is an energy splitting, of what would otherwise be degenerate quantum states, caused by a spin-orbit interaction in conjunction with interfacial electric fields in an asymmetrical semiconductor heterostructure. The magnitude of the energy split is proportional to the electron wave number. Theoretically, electron-energy states would be split by the Rashba effect, and spin-polarized currents would be extracted by resonant quantum-mechanical tunneling. Accordingly, a spin-polarizing device based on these principles would be denoted an asymmetric resonant interband (or intraband, as the case may be) tunneling diode [a-RITD].



Electron-Energy-Band Alignments depicted here schematically are those of a proposed InAs/GaSb/AlSb a-RITD device for achieving current spin polarization >1. The shaded and cross-hatched regions represent bandgaps.

One possible structure of a device according to the present proposal would be similar to the a-RITD structure described previously: The device would comprise an asymmetric composite InAs-GaSb well, sandwiched between AlSb barriers and degenerately-n-doped InAs emitter and collector electrodes (see figure). Unpolarized electrons from the conduction band of the InAs emitter electrode would tunnel through one AlSb barrier and travel through an asymmetric InAs-GaSb quantum well, where Rashba spin splitting would occur; they would then tunnel through the other AlSb barrier into the conduction band of the InAs collector electrode. The device would be operated in an intraband-tunneling regime, in which no bias would be applied through the thickness of the stack of layers. A lateral electric (an electric field parallel to the planes of the layers) would be applied to emitter layer. With appropriately chosen thicknesses of layers and an appropriate value of the applied lateral electric field, it should be possible to achieve $|P_J|>1$.

This work was done by David Z. Ting of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
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