where $\sigma_{s\parallel} \equiv \sigma_s^0$ and $\sigma_{s\perp} \equiv \sigma_s$. When the degree of the anisotropy is small, the spin current becomes

$$\frac{j_s^{\mathrm{loc},z}}{E} = \sigma_{s\parallel} \left(1 + \frac{1}{2} \left(\frac{\sigma_{s\perp}}{\sigma_{s\parallel}} \right)^2 \sin^2 \theta \right). \tag{39}$$

We define the magnitude of the spin AMR as

$$\frac{\Delta \rho_s}{\rho_{s\perp}} \equiv \frac{\rho_{s\parallel} - \rho_{s\perp}}{\rho_{s\perp}} = \frac{\delta\sigma_s/\sigma_s}{1 - \delta\sigma_s/\sigma_s}, \tag{40}$$

where $\rho_{s\alpha} \equiv (\sigma_{s\alpha})^{-1}$ $(\alpha = \parallel, \perp)$.

V. SPIN INJECTION

We have thus derived the explicit expression for the spin chemical potential within the linear response theory. Let us apply Eq. (30) to a ferromagnetic-normal metal junction with an insulating barrier, used in the nonlocal spin injection experiments [5], depicted in Fig. 4(a). When the voltage is applied perpendicular to the interface (we choose the x axis in this direction), the electric field is uniform inside the ferromagnet and the normal metal except at the interface. Writing the voltage drop at the interface (chosen as at $x = 0$) by V_{FN}, we obtain

$$\nabla \cdot \boldsymbol{E} \simeq \delta(x) V_{\mathrm{FN}}/d, \tag{41}$$

where d is the width of the interaface, which is treated as small enough compared with the electron mean free path, resulting in the delta function in $\nabla \cdot \boldsymbol{E}$. In totally unpolarized non-magnetic metals, namely, if $\sigma_+ = \sigma_-$ and $D_+ = D_-$, the correlation function in Eq. (31) always vanishes. As is naively guessed, therefore, spin injection thus requires an effective spin polarization close to the interface, induced by the exchange interaction with the ferromagnet. This spin polarization is expected to be localized within a short distance of a few lattice constants from the interface. Let us approximate the interface polarization by introducing spin-dependent diffusion constant and the density of states, $\overline{D}_\sigma$ and $\overline{\nu}_\sigma$, respectively, at the interface. The long-range behavior of the spin correlation function in the non-magnetic side is then obtained as

$$\chi^{(\mathrm{N})}(\boldsymbol{x}) = -\frac{e}{4\pi} (\sum_\sigma \sigma \overline{D}_\sigma \overline{\nu}_\sigma) \frac{e^{-|\boldsymbol{x}|/\ell_s}}{|\boldsymbol{x}|}, \tag{42}$$