



US011974506B2

(12) **United States Patent**
Wu et al.

(10) **Patent No.:** US 11,974,506 B2
(45) **Date of Patent:** Apr. 30, 2024

(54) **SPIN-ORBIT TORQUE DEVICE**

(71) Applicants: NATIONAL TAIWAN UNIVERSITY, Taipei (TW); Academia Sinica, Taipei (TW)

(72) Inventors: Po-Hsun Wu, Taipei (TW); Ssu-Yen Huang, Taipei (TW); Chia-Ling Chien, Cockeysville, MD (US); Danru Qu, Taipei (TW)

(73) Assignees: NATIONAL TAIWAN UNIVERSITY, Taipei (TW); ACADEMIA SINICA, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 198 days.

(21) Appl. No.: 17/528,366

(22) Filed: Nov. 17, 2021

(65) **Prior Publication Data**

US 2022/0158084 A1 May 19, 2022

Related U.S. Application Data

(60) Provisional application No. 63/115,660, filed on Nov. 19, 2020.

(51) **Int. Cl.**
H10N 52/00 (2023.01)
H10N 50/85 (2023.01)

(52) **U.S. Cl.**
CPC H10N 52/101 (2023.02); H10N 50/85 (2023.02)

(58) **Field of Classification Search**
CPC H10N 52/101; H10N 50/85; H10N 50/00; H10N 50/10; H10N 50/20; H10N 52/85
See application file for complete search history.

(56) **References Cited**

PUBLICATIONS

Keller, Near-unity spin Hall ratio Ni_xCu_{1-x} alloys, American Physical Society, Jun. 2019, pp. 214411-1-214411-14.*

* cited by examiner

Primary Examiner — Latanya N Crawford Eason

(74) Attorney, Agent, or Firm — BACON & THOMAS, PLLC

(57) **ABSTRACT**

A spin-orbit torque device is disclosed, which includes: a magnetic layer; and a non-magnetic layer adjacent to the magnetic layer and comprising a spin-Hall material, wherein the spin-Hall material comprises Ni_xCu_{1-x} alloy, and x is in a range from 0.4 to 0.8.

7 Claims, 8 Drawing Sheets

