

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

(10) **Patent No.:** **US 6,611,002 B2**
(45) **Date of Patent:** **Aug. 26, 2003**

(54) **GALLIUM NITRIDE MATERIAL DEVICES AND METHODS INCLUDING BACKSIDE VIAS**

(75) Inventors: **T. Warren Weeks**, Raleigh, NC (US);
Edwin L. Piner, Cary, NC (US);
Ricardo M. Borges, Morrisville, NC (US);
Kevin J. Linthicum, Angier, NC (US)

(73) Assignee: **Nitronex Corporation**, Raleigh, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/792,414**

(22) Filed: **Feb. 23, 2001**

(65) **Prior Publication Data**

US 2002/0117681 A1 Aug. 29, 2002

(51) **Int. Cl.⁷** **H01L 33/00**

(52) **U.S. Cl.** **257/94; 257/96; 257/101; 257/103; 257/190; 257/191; 257/462; 438/173; 438/172; 438/778; 438/779**

(58) **Field of Search** **257/94, 96, 103, 257/101, 190, 191, 192, 194, 462, 347; 438/173, 172, 778, 779**

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,985,742 A * 1/1991 Pankove 357/34
5,192,987 A 3/1993 Khan et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

| | | |
|----|---------------|---------|
| DE | 199 31 300 A1 | 2/2000 |
| EP | 0 740 376 A1 | 10/1996 |
| EP | 0 852 416 A1 | 7/1998 |
| EP | 0 951 055 A2 | 10/1999 |
| FR | 2 809 534 A | 11/2001 |
| JP | 09326534 A | 12/1997 |
| JP | 10135519 A * | 5/1998 |
| JP | 10242584 A | 9/1998 |
| WO | WO00/33365 A1 | 6/2000 |
| WO | WO01/37327 A1 | 5/2001 |
| WO | WO01/43174 A2 | 6/2001 |
| WO | WO01/47002 A2 | 6/2001 |
| WO | WO01/59819 A1 | 8/2001 |

Primary Examiner—Nathan J. Flynn

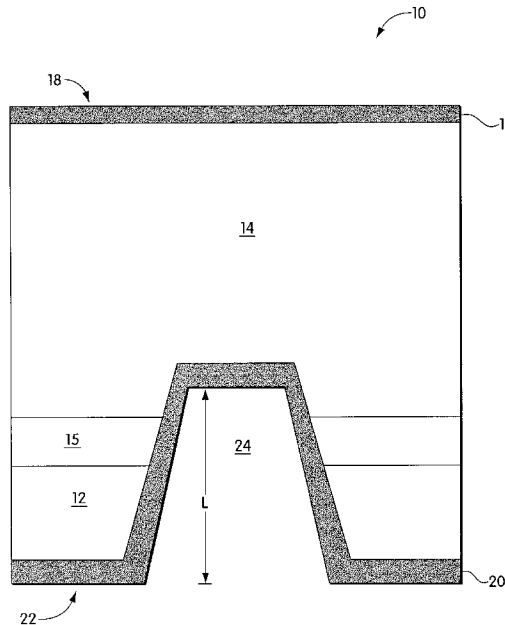
Assistant Examiner—Remmon R. Fordé

(74) *Attorney, Agent, or Firm*—Wolf, Greenfield & Sacks, P.C.

(57) **ABSTRACT**

The invention includes providing gallium nitride material devices having backside vias and methods to form the devices. The devices include a gallium nitride material formed over a substrate, such as silicon. The device also may include one or more non-conducting layers between the substrate and the gallium nitride material which can aid in the deposition of the gallium nitride material. A via is provided which extends from the backside of the device through the non-conducting layer(s) to enable electrical conduction between an electrical contact deposited within the via and, for example, an electrical contact on the topside of the device. Thus, devices of the invention may be vertically conducting. Exemplary devices include laser diodes (LDs), light emitting diodes (LEDs), power rectifier diodes, FETs (e.g., HFETs), Gunn-effect diodes, and varactor diodes, among others.

51 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

| | | | | | | |
|---------------|---------|---------------------|----------------|---------|-------------------|---------|
| 5,296,395 A | 3/1994 | Khan et al. | 6,051,849 A | 4/2000 | Davis et al. | |
| 5,389,571 A | 2/1995 | Takeuchi et al. | 6,060,730 A * | 5/2000 | Tsutsui | 257/103 |
| 5,393,993 A | 2/1995 | Edmond et al. | 6,064,082 A * | 5/2000 | Kawai et al. | 257/192 |
| 5,438,212 A | 8/1995 | Okaniwa | 6,121,121 A | 9/2000 | Koide | |
| 5,523,589 A | 6/1996 | Edmond et al. | 6,121,634 A * | 9/2000 | Saito et al. | 257/86 |
| 5,739,554 A | 4/1998 | Edmond et al. | 6,153,010 A | 11/2000 | Kiyoku et al. | |
| 5,760,426 A | 6/1998 | Marx et al. | 6,177,688 B1 | 1/2001 | Linthicum et al. | |
| 5,838,706 A | 11/1998 | Edmond et al. | 6,201,262 B1 | 3/2001 | Edmond et al. | |
| 5,864,171 A | 1/1999 | Yamamoto et al. | 6,239,033 B1 * | 5/2001 | Kawai | 438/693 |
| 5,874,747 A * | 2/1999 | Redwing et al. | 6,255,198 B1 | 7/2001 | Linthicum et al. | |
| 5,905,275 A * | 5/1999 | Nunoue et al. | 6,261,929 B1 | 7/2001 | Gehrke et al. | |
| 5,928,421 A | 7/1999 | Yuri et al. | 6,265,289 B1 | 7/2001 | Zheleva et al. | |
| 6,045,626 A | 4/2000 | Yano et al. | 6,355,497 B1 | 3/2002 | Romano et al. | |

* cited by examiner

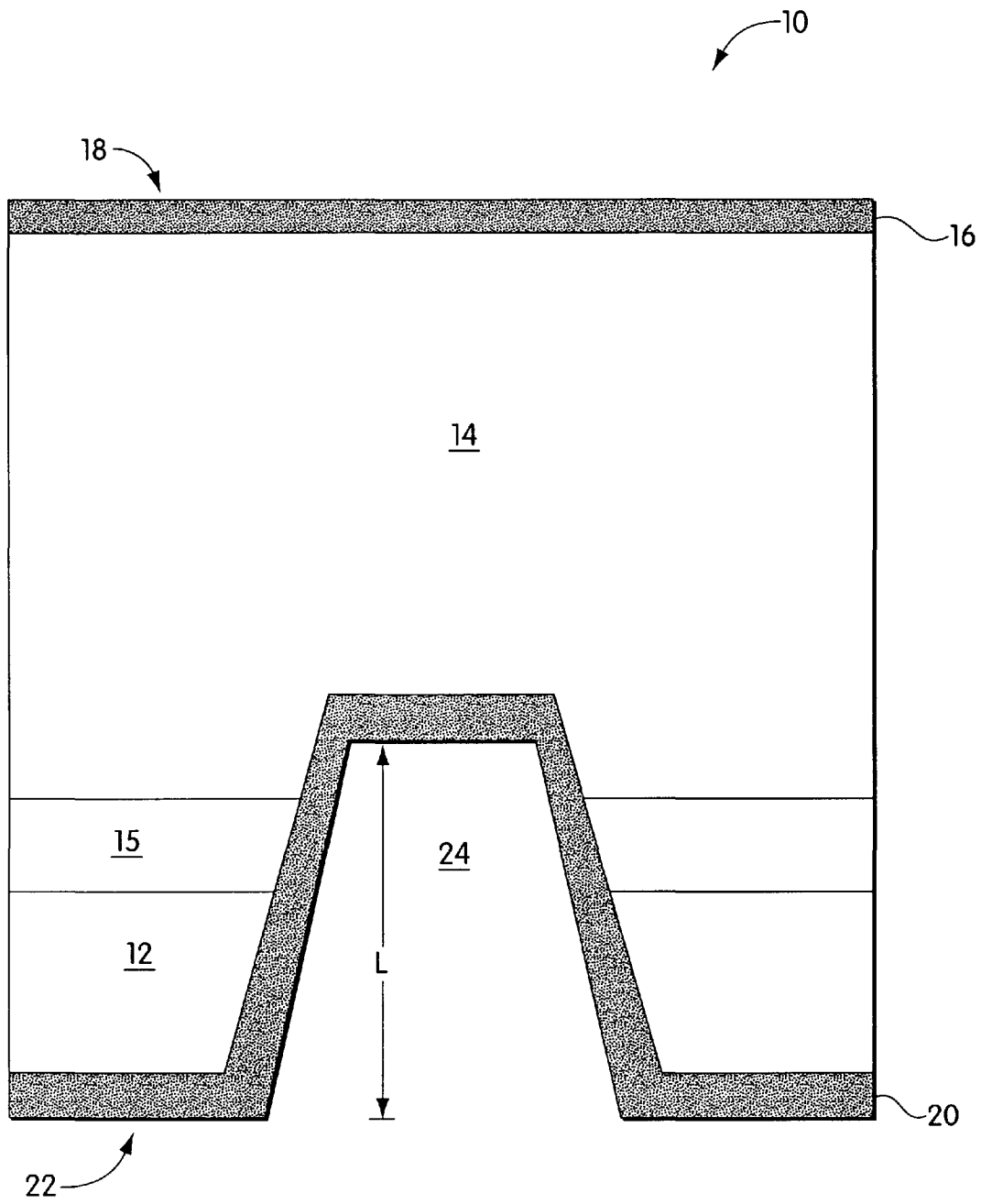


Fig. 1

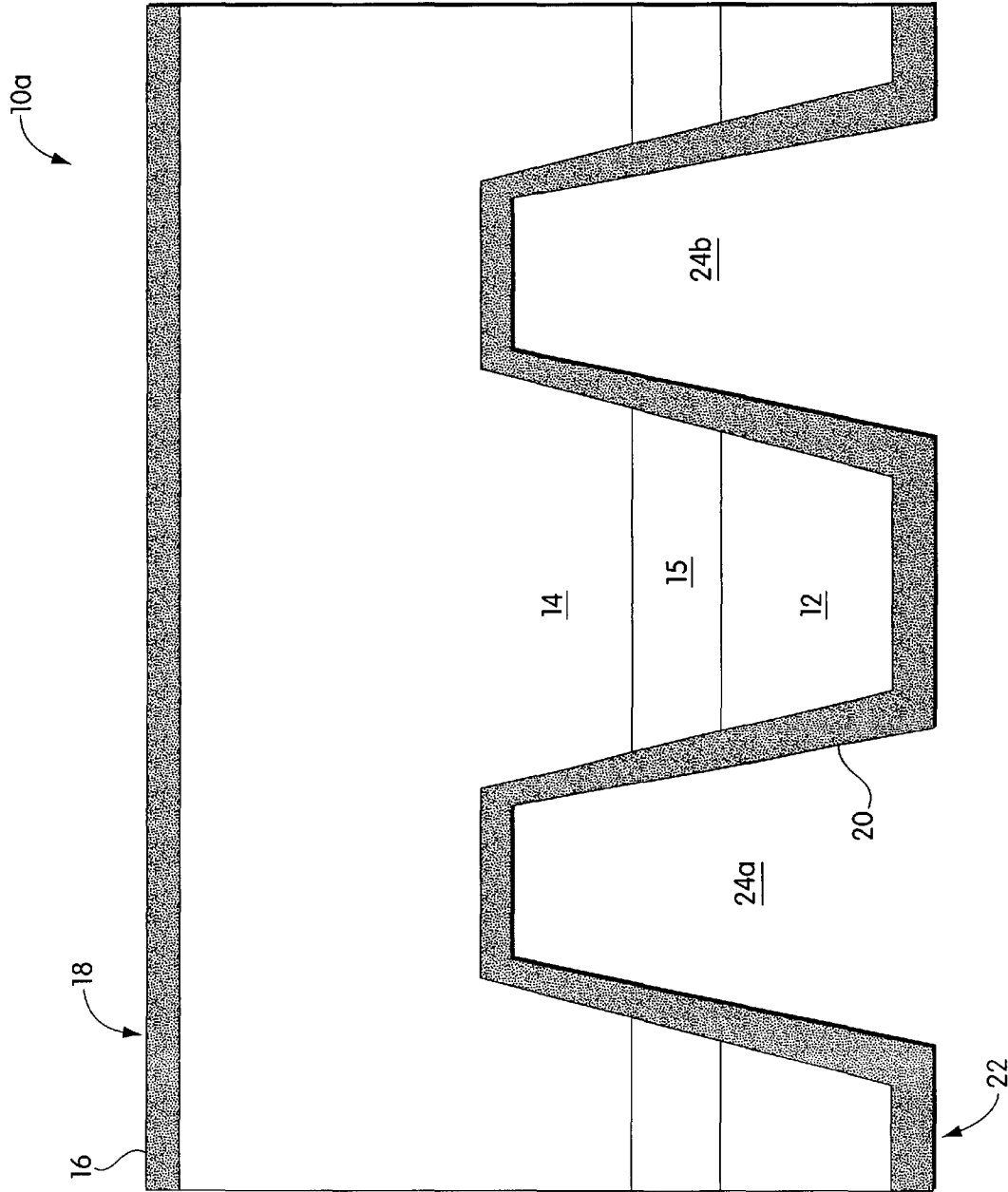


Fig. 2

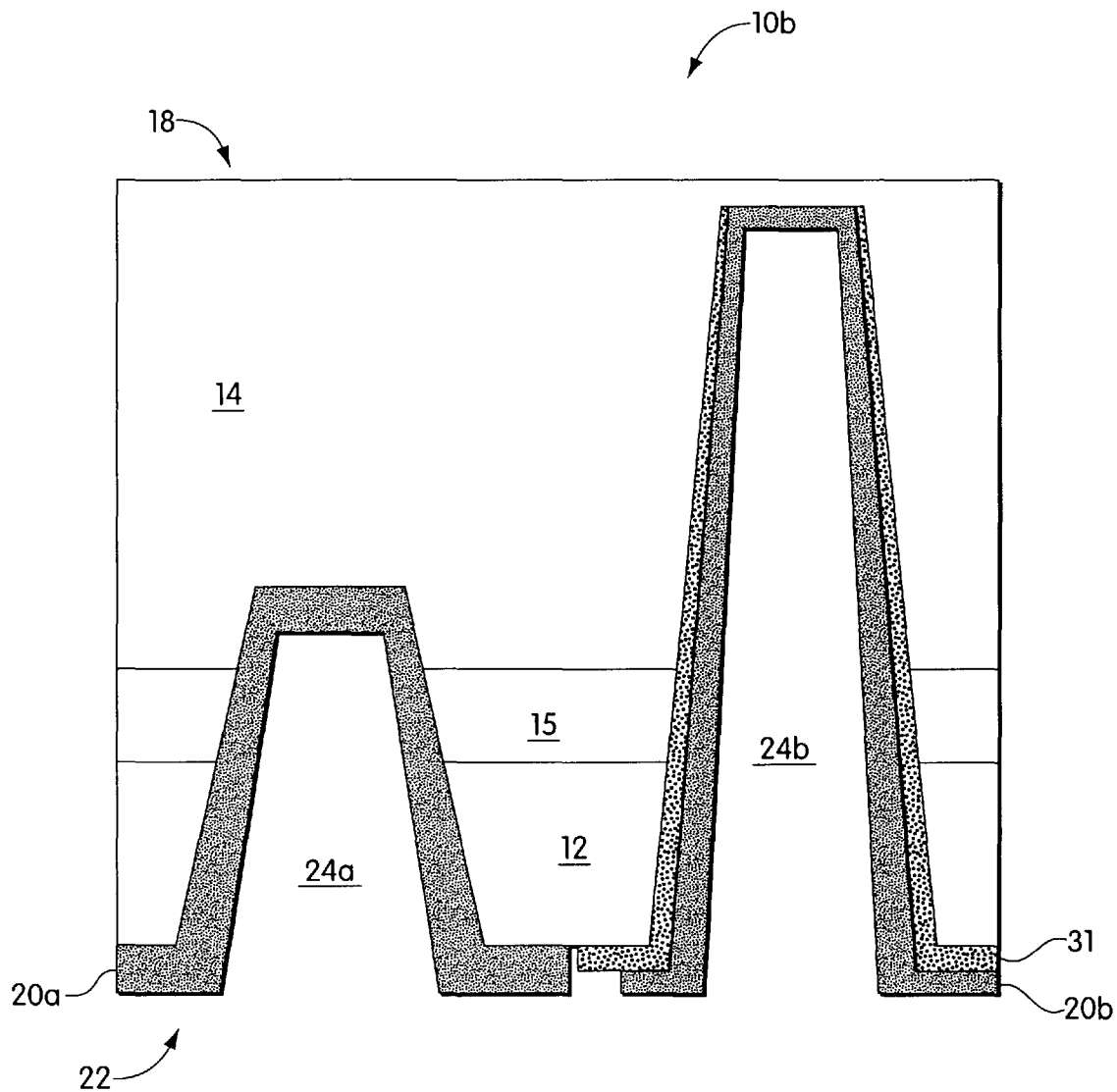


Fig. 3

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.