



## (51) International Patent Classification:

A61K 39/44 (2006.01) C12N 5/10 (2006.01)  
C12N 15/13 (2006.01) C07K 16/28 (2006.01)  
C12N 15/63 (2006.01) A61K 39/395 (2006.01)  
C12N 1/19 (2006.01) A61P 35/00 (2006.01)  
C12N 1/21 (2006.01)

## (21) International Application Number:

PCT/US2011/059973

## (22) International Filing Date:

9 November 2011 (09.11.2011)

## (25) Filing Language:

English

## (26) Publication Language:

English

## (30) Priority Data:

61/413,173 12 November 2010 (12.11.2010) US

## (71) Applicants (for all designated States except US):

CHEVRON U.S.A. INC. [US/US]; 6001 Bollinger Canyon Road, San Ramon, California 94583 (US). LOS ALAMOS NATIONAL SECURITY LLC [US/US]; Mail Stop A187, P.O. Box 1663, Los Alamos, New Mexico 87544 (US).

## (72) Inventors; and

(75) Inventors/Applicants (for US only): VU, Cung Khac [US/US]; 2811 Lafayette Street, Houston, Texas 77005

(US). NIHEI, Kurt T. [US/US]; 5839 Amy Dr., Oakland, California 94618 (US). JOHNSON, Paul A. [US/US]; 04 CR 113 South, Santa Fe, New Mexico 87506 (US). GUY-ER, Robert A. [US/US]; 2020 Dickerson Rd., Reno, Nevada 89503 (US). TEN CATE, James A. [US/US]; 542 Todd Loop S, Los Alamos, New Mexico 87544 (US). LE BAS, Pierre-Yves [FR/US]; 625 La Bajada, Los Alamos, New Mexico 87544 (US). LARMAT, Carene S. [FR/US]; 1051 11th Street, Los Alamos, New Mexico 87544 (US).

(74) Agents: PEREZ, Robert C.F. et al.; Pillsbury Winthrop Shaw Pittman LLP, P.O. Box 10500, McLean, Virginia 22102 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR GENERATING MICRO-SEISMIC EVENTS AND CHARACTERIZING PROPERTIES OF A MEDIUM WITH NON-LINEAR ACOUSTIC INTERACTIONS

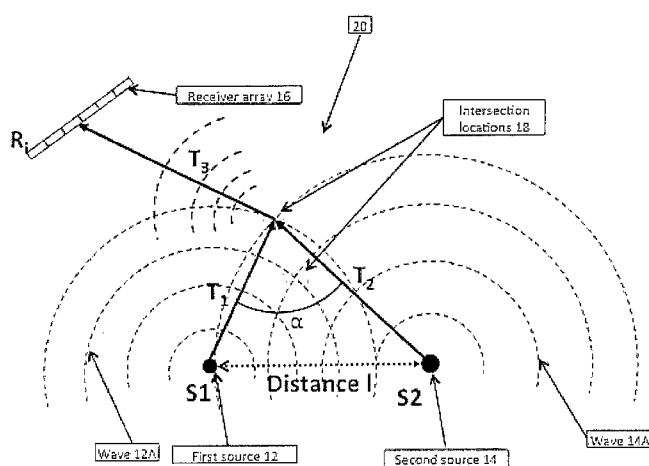


FIG.1

(57) Abstract: A method and system for generating a micro-seismic event in a medium from a non-linear interaction to characterize the medium is provided. The method includes generating, by a first acoustic source, a first coded acoustic signal comprising a first plurality of pulses arranged as a time sequence, each pulse comprising a modulated signal at a central frequency; and generating, by a second acoustic source, a second coded acoustic signal comprising a second plurality of pulses arranged as a time sequence, wherein each pulse comprises a modulated signal and a central frequency of the modulated signal within each pulse in the second plurality of pulses is a selected fraction d of the central frequency of the modulated signal for the corresponding pulse in the first plurality of pulses. The method further includes receiving, by a receiver, a detected signal including a third signal being generated by a non-linear mixing process from the first acoustic signal and the second acoustic signal in the mixing zone; performing, by a processor, data processing on the received signal, or correlating with a coded signal template, or both, to extract the third signal generated by the non-linear mixing process over

noise or over signals generated by a linear interaction process, or both, to obtain an emulated micro-seismic event signal occurring at the mixing zone; and characterizing properties of the medium or creating a 3D image of the properties of the medium, or both, based on the emulated micro-seismic event signal.



**(84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS,

SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*